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Lake Frances Dams, Valier, Montana, Pondera County, MT-1125-East Dam, MT-1484-North Dam

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LAKE FRANCES DAMS
VALIER, MONTANA
PONDERA COUNTY
MT-1125-EAST DAM
MT-1484-NORTH DAM

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

PONDERA COUNTY CANAL
AND RESERVOIR COMPANY
(OWNER/OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON
OCTOBER, 1980

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation (DNRC), the City of Conrad, and the Pondera County Canal and Reservoir Company, CH2M HILL inspected Lake Frances Dams on October 29, 1979, under the authority of Public Law 92-367. A return visit was made on October 31, 1979, for inspection of the outlet works. Lake Frances East Dam is located about 3 miles southeast of Valier, Montana, and the North Dam is located about 2 miles west of Valier.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Lake Frances Dams are owned and operated by the Pondera County Canal and Reservoir Company. The dams and reservoir are used to store water for irrigation and for municipal use in the City of Conrad. The 57-foot-high East Dam (main dam), MT-1125, impounds 133,000 acre-feet of water at dam crest, elevation 3822 feet National Geodetic Vertical Datum (NGVD), and the 22-foot-high North Dam controls 95,000 acre-feet at elevation 3822. On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), both dams are large in size. East Dam is located such that its failure would cause considerable downstream flooding of ranches and would leave the City of Conrad without a water supply. A failure of the North Dam would also cause flooding, but the City water system would still be operable. No dam breach analysis or routing of a dam breach flood was made for either of the dams for the downstream area in this report. The conclusions on probable damage are based on a brief field visit and engineering judgment.

East Dam is classified as having a high (Category 1) downstream hazard potential, and North Dam is classified as having a significant (Category 2) downstream hazard potential.

The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that a large-sized project with a high downstream hazard potential be capable of safely handling the probable

maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated PMF was developed for the 21.5-square-mile drainage basin during this dam safety study. The PMF resulting from the 72-hour storm has an estimated volume of 22,550 acre-feet. The project has no spillway. The outlet works at the East Dam has a maximum discharge capacity of about 950 c.f.s. with the reservoir at top of dam, elevation 3822 feet NGVD. Assuming the outlet works safely passes its maximum discharge with fully opened gates, it is estimated that the project can control the PMF if the reservoir is filled to no more than 105,000 acre-feet (elevation 3817.1 feet) for normal reservoir operation. However, a visual inspection of the outlet works raised serious concerns about the reliability of the outlet conduits when under pressure.

The intake structure for the outlet works at the North Dam shows extensive concrete spalling and exposed reinforcement. Only one of the three conduits is in operating condition. The outlet works for the East Dam is in poor condition. The conduits contain cracks up to 3 inches wide and show some exposed reinforcement. Cavitation damage is present downstream of the upstream gate valve on the lower conduit. None of the gate valves are vented.

The conduits are under pressure for all operating conditions, which may cause water to be forced through the cracks into the embankment, leading to a potential piping failure of the dam. The conduits are pressurized so water can be drawn off for the City of Conrad water supply.

Both the North and East Dams are constructed of materials that would quickly erode and rapidly fail when overtopped by flood waters. A visual inspection of the East Dam embankment showed a 150-foot-long, longitudinal crack on the downstream slope and several seepage areas near the downstream toe. At the North Dam, seepage and evidence of previous seepage were noticed along much of the downstream toe. Several areas along the upstream slope on North Dam have been oversteepened by wave erosion. A corrugated metal parapet wall along the top of the East Dam is not completly effective in protecting the embankment from wind-generated wave attack. No stability analysis of either embankment is on file. Based on a review of the East Dam information, the embankment stability may be in conformance with the recommended guidelines. However, the present condition of the outlet conduit could cause an embankment failure by piping. It is our judgment that the present condition does not represent an emergency situation but does require immediate attention.

The North Dam embankment may be in conformance with the recommended guidelines; however, the information is not available for stability evaluation.

RECOMMENDATIONS

Because of storage between normal pool and dam crest, the present project provides a certain degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety while preserving the flood protection.

Develop and immediately implement an effective downstream warning system for use in the event of a structural failure or dam overtopping hazard. Reevaluate the present City of Conrad water withdrawal system, which now requires pressurizing the outlet conduit. Consider developing a system independent of the outlet conduit. Repair cracks in the outlet conduits or fit conduits with liners. Repair cavitation damage at upstream gate valve of lower conduit. Provide air vents downstream of all valves. Evaluate reliability of canal headworks system in shutting off flow to the lake. Repair concrete intake structure at North Dam outlet works. The project can control the estimated PMF with freeboard of 0.3 feet; however, this should be reevaluated if future needs require a change from present reservoir operations. Conduct periodic inspections of the project at least at 3-year intervals by engineers experienced in dam design and construction.

Prior to implementing any report recommendations, the Owner is urged to coordinate with the Montana Department of Natural Resources and Conservation.

RICHARD L. FOSTER
2646 E

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. General

Federal ID Nos.: East Dam	MT-1125
North Dam	MT-1484
Owner/Operator	Pondera County Canal and Reservoir Company
Date Constructed	1908-09
Purpose	Irrigation and Municipal Water Supply
Location: East Dam	Sections 23 and 24, T29N, R5W, Principal Meridian
North Dam	Section 32, T30N, R5W and Sections 5 and 6, T29N, R5W, Principal Meridian
County, State	Pondera County, Montana
Watershed	Unnamed tributary of Dry Fork Marias River
USGS Quadrangles	Lake Frances Valier
Downstream Hazard Potential:	
East Dam	Category 1 (High)
North Dam	Category 2 (Significant)

2. Reservoir

Surface Area at Normal Maximum Reservoir	5,300 acres
Drainage Area	21.5 square miles (8.3-square-mile lake and 13.2-square-mile land area)
East Dam	
Storage at Normal Maximum Pool (Elevation 3817.1 feet NGVD)	105,000 acre-feet

Storage at Dam Crest (Elevation 3822 feet NGVD)	133,000 acre-feet
Surcharge Storage	28,000 acre-feet

North Dam

Storage at Normal Maximum Pool (Elevation 3817.1 NGVD)	67,000 acre-feet
Storage at Maximum Pool (Elevation 3822.0 NGVD)	95,000 acre-feet
Surcharge Storage	28,000 acre-feet

3. Outlet Works, East Dam

Conduits	Two 4.5-foot-diameter reinforced concrete, transitioning to a single 7-foot-diameter conduit
Conduit length	300 feet
Gates	Two 4.5-foot-diameter gate valves in upstream wet well tower and two 5-foot-diameter slide gates in dam axis wet well tower, and two 4- by 7-foot slide gates at outlet structure
Capacity with Reservoir at Dam Crest	950 c.f.s.

4. Outlet Works, North Dam

Conduits	One 5-foot diameter and two 4- by 5-foot reinforced concrete conduits
Conduit Length	70 feet
Gates	Three slide gates at upstream face
Capacity with Reservoir at Dam Crest	
Present condition (only 5-foot diameter conduit operating)	500 c.f.s.

All conduits operating	1,300 c.f.s.

5. Dam Embankments

East Dam

Type	Earth
Length	700 feet
Crest Width	20 feet
Crest Elevation	3822.0 feet NGVD
Hydraulic Height (Crest to Toe)	57 feet
Upstream Slope	1 V on 2 H upper; 1 V on 3 H lower
Downstream Slope	1 V on 2 H upper; 1 V on 3 H lower

North Dam

Type	Earth
Length	6,000 feet (approx.)
Crest Width	15 feet
Crest Elevation	3824.5 feet NGVD
Hydraulic Height (Crest to Toe)	22 feet
Upstream Slope	1 V on 2 H
Downstream Slope	1 V on 1.5 H

Chapter 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Lake Frances Dams, owned by the Pondera County Canal and Reservoir Company.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phase study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.

(2) based upon an evaluation of the available data and a visual inspection.

(3) performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.

(4) not intended to include extensive explorations and analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing,

material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigation with the exception of situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigation outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on a brief visual inspection of the project and a detailed review of available construction plans. Inspection procedures and criteria are those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the October 29, 1979, inspection included:

Richard Eckerlin, Geologist, Seattle District Corps of Engineers
Art Taylor, State of Montana Department of Natural Resources and Conservation
Fay Stokes, Pondera County Canal and Reservoir Company
Vernon Stokes, Pondera County Canal and Reservoir Company
Donatus Kronebusch, Pondera County Canal and Reservoir Company

Gerald Vandenacre, Pondera County Canal and Reservoir Company
Ralph Dunahoo, City of Conrad Public Works

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles Bubenik, Geotechnical Engineer, Team Leader
Jerry Jacksha, Geotechnical Engineer
Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the State of Montana DNRC, the Pondera County Canal and Reservoir Company, and the City of Conrad. Their written comments are enclosed in the appendix of the report.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

The Lake Frances project includes two embankments: the East Dam and the North Dam; the two impound Lake Frances (see Plate 1). The East Dam (main dam) is located on an unnamed tributary of the Dry Fork Marias River, in Pondera County, Montana. The dam is approximately 3 miles southeast of Valier. The North Dam is approximately 2 miles west of Valier. A small dike (unnamed and not classified as a dam) is located just southeast of Valier (Photo 1). The project is currently listed as having a high (Category 1) downstream hazard potential. The Federal identification numbers for the East Dam and the North Dam are MT-1125 and MT-1484, respectively. The East Dam is about 57 feet high, the North Dam is about 22 feet high, and the dike is about 4 feet high. Lake Frances has a storage of about 133,000 acre-feet at top of dam, elevation 3822 feet NGVD of which 133,000 acre-feet is controlled by East Dam and 95,000 acre-feet is controlled by North Dam. A failure of North Dam would cause flooding of agricultural land and may flood a few ranch homes. No homes were observed within the flood plain immediately downstream of East Dam; however, Lake Frances is used as the water supply for the City of Conrad and a failure of the East Dam would leave the city without water. There are some ranches, bridges, and a railroad along the Dry Fork Marias River that could be flooded as a result of the East Dam failure. A 1973 Corps of Engineers inspection report (Ref. 3) on Lake Frances East Dam gives the following summary of an aerial reconnaissance downstream of the dam:

Buildings. Ten homes appear to be entirely or partially within an assumed flood plain. Seven of these are farms which include numerous out-buildings such as sheds and barns. The three remaining homes make up the small town of Ledger.

Bridges. There are several large bridges crossing the water courses. The largest of these are the interstate highway bridges near Conrad. These bridges are prestressed concrete structures consisting of four spans and are about 200 feet in length. There are seven railroad bridges varying in length from about 60 to 300 feet. In addition, there are five county or state highway bridges.

Railroad. About 15 miles below the dam, the Burlington Northern Railroad follows the course of the Dry Fork for approximately 12 miles. Erosion damage to the railroad embankment would probably result from high velocity flows should dam failure occur.

Miscellaneous Structures. Other structures subject to damage by water from East Dam failure include an aggregate plant, two grain silos, a barley mill, and a power transmission line which crosses the water course a short distance below the dam.

A final consideration, but a very important one, is the domestic water supply for the City of Conrad, which taps into the outlet works below the dam. Should the dam fail, Conrad would be without water. On the basis of the above information and in accordance with the recommended guidelines, the project is large in size and the downstream hazard potential is high (Category 1).

The 5,300-acre reservoir is used for storing irrigation water and for municipal water supply. The project was constructed in 1909 and is owned and operated by the Pondera County Canal and Reservoir Company.

The low-level outlet for the East Dam consists of two concrete conduits controlled by six slide gates (Plate 5). The project has no spillway, but there is a gated outlet works at the North Dam that discharges into one canal of the Reservoir Company (see Plate 4). The reservoir is an off-channel storage area and is filled by canal diversion.

1.2.2 Regional Geology and Seismicity

The regional geology and seismicity were addressed in a memorandum by R. D. Eckerlin (Ref. 2). The following information is based on parts of that memorandum.

> Lake Frances Dam lies in the Great Plains physiographic province, in a region of subdued knob and kettle topography left by the stagnating glaciers that once occupied the region. The reservoir lies on the western flank of the Marias River Saddle section of the Sweetgrass Arch. A surface mantle of unconsolidated deposits is underlain by the Virgelle Sandstone, and softshale and crossbedded sandstone of the overlying Two Medicine Formation. The

> bedrock formations dip very gently northwest. The Two Medicine Formation is the most widespread unit in the area.
>
> Lake Frances, east of the Rocky Mountains, lies in an area of moderate seismic activity. The Inspection Guidelines Zoning Map shows the site in Zone 2, which has a potential for moderate earthquake damage. Although the zoning map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design for the site. Algermissen (1976) estimates a 90 percent chance of a 0.04 g acceleration being felt at this dam in a 50-year period. Western Montana is seismically active along the Rocky Mountain Front. This area shows the greatest chance of producing the highest acceleration Lake Frances dams would experience. The seismicity east of the front is quite diffuse and there is no lineup of epicenters which indicate Lake Frances to be in a high risk area.

1.2.3 Site Geology

The site geology also was addressed in the R. D. Eckerlin memorandum (Ref. 2). The following information is based on parts of that memorandum.

> There are no known geological investigations for this project. The East Dam spans a ravine cut in sandstone bedrock and is presumed to be founded on a thin mantle of terrace deposits overlying the sandstone (Plate 2). The sandstone is presumed to be the basal part of the Two Medicine Formation. Terrace deposits are composed of bedded gravelly silty sand and sandy silt.
>
> The North Dam is presumed to be founded on terrace sediments consisting of sand, silt, and some gravel. The extent of foundation preparation is not known. A 1920 typical embankment plan on file (Plate 7) shows a "yellow clay" layer existed beneath "gravels;" however, this was not confirmed by any known borings or test pits.
>
> Sandstone bedrock of the Two Medicine Formation underlies Lake Frances and comprises the surrounding land. The lake shoreline is very gentle except for an occasional near vertical slope that stands less than 5 feet above the maximum reservoir surface. Wave erosion of the lake shoreline occurs, but is of minor consequence.

1.2.4 Design and Construction History

The Lake Frances project, currently owned by Pondera County Canal and Reservoir Company, was designed by Ford, Davis,

and Bacon of New York, New York. Construction of the project was completed in 1909 for the original owners, Montana Land and Water Company. At about 1919 the 18-foot-wide bench was added to the downstream slope of the East Dam. Between 1920 and 1936, improvements were made at the East Dam downstream left abutment, including a gravel fill, a concrete retaining wall, and drain pipes to control a seepage problem. Several equipment modifications and operating changes of the outlet works at East Dam have been made throughout the life of the project, some of which are discussed hereafter in this report.

Chapter 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Outlet Works, East Dam

The low-level outlet works for Lake Frances East Dam is located through the embankment near the center of the dam. The outlet works consists of two cast-in-place concrete conduits that merge into a single conduit near the downstream toe of the dam. The two conduits are vertically aligned such that one conduit sits directly above the other. Flows through the conduits are controlled by two gate valves and four slide gates (Plate 5).

The outlet works has two wet-well control towers. Each houses one hand-crank gate control for the upper conduit and one for the lower conduit. The upstream wet-well tower is located in the reservoir near the upstream toe of the dam and is reached by about 80 feet of walkway. The downstream wet well is located near the axis of the dam. The upper conduit extends about 87 feet between the two wet wells. The lower conduit extends about 100 feet from the upstream side of the upstream wet well to the wet well near the axis of the dam. The cross sections of both conduits between the two wet wells vary randomly from 52 inches in diameter to 54 inches in diameter.

Downstream of the dam axis wet well, the upper conduit changes to 5-foot diameter and extends approximately 51 feet to another change in cross section. This cross section is a modified circular section, 6.4 feet wide, and 6.3 feet high, with 2.7-foot vertical side walls (Plate 5). This section continues for about 29 feet to the point where the upper and lower conduits merge. The lower conduit varies in cross section from a 4.5-foot-diameter to a 6.6-foot-wide modified circular section similar to the one described for the upper conduit. The two conduits merge about 80 feet downstream of the dam axis wet well by use of a 21-foot-long transition to a single 7-foot-diameter conduit that continues another 51 feet to the outlet structure.

The outlet structure is a 10-foot-high wet well fitted with two 4- by 7-foot slide gates (Photo 2). These downstream gates are operated to pressurize the conduits so water can be withdrawn for the City of Conrad's water supply (see paragraph 2.1.2 for the municipal water supply connection with the low-level outlet). Downstream of the gates is a set of divergent wing walls connected by a short apron. Because of tailwater in the downstream stilling pool, the outlet structure could not be inspected for undercutting.

A return visit was made to Lake Frances East Dam on October 31, 1979, after the stilling pool at the toe of the dam had been lowered to allow access to the outlet conduit. The gate valves at the upstream wet well tower were used as the operating valves so that the entire lengths of both conduits were free for inspection. Areas of cavitation damage were observed in the steel and the concrete immediately downstream of the upstream gate valve on the lower conduit. Cavitation has formed a 1/2-inch-diameter hole in the gate housing and the hole was spraying water into the conduit. Mr. Stokes mentioned that the hole has been there for many years and that it usually becomes silted shut after a whole winter with the gate shut. Neither the upper nor lower gate valves at the upstream wet well were vented, but no cavitation damage was observed at the upper gate valve. Both the upper and lower conduits between the two wet wells had steel sleeves inserted at various locations. The sleeves were about 49 inches in diameter, 3/8-inch thick, riveted steel sections of variable length.

It was observed at some sleeves that pieces of redwood had been driven between the concrete conduit and the steel sleeves to hold the sleeves in place or to stop leakage. Other sleeves appeared to have been grouted into place. The material from behind one of the sleeves has been washed away and the sleeve has twisted such that one side was in contact with the concrete conduit and the opposite side was away from the concrete conduit by 3 inches. Apparently the sleeves were added at joints or cracks in the conduit to stop leakage. No water was observed leaking from behind any of the sleeves.

The upper conduit contained 2 to 3 inches of silt, with larger localized accumulations, which may indicate piping of embankment material into the conduit. However, no leaks into the conduit were observed to account for the material, and it was concluded that the silt may have settled out of the water in the conduit. The lower conduit downstream of the dam axis wet well to the transition contained several cracks. The average width was about 1.5 inches, but the largest crack was 3 inches wide. Sections of the upper conduit showed exposed reinforcement. The upper conduit also contained a few rocks up to 8 inches in diameter, and one was jammed behind the slide gate for the lower conduit at the dam axis wet well. The rocks may be riprap from the upstream face of the dam. The conduits appeared generally to be in rough condition with many abrupt changes in the flow sections and some exposed reinforcement.

The discharge rating for the outlet works was developed for two possible gate settings. The first setting was with all gates fully open except for the gate valve of the upper conduit at the upstream wet well. The conduit was assumed to flow full with a Manning's "n" varying from 0.019 to

0.014. The maximum discharge with the reservoir at top of main dam, elevation 3822 feet NGVD, was estimated to be 530 c.f.s. The second rating was for the setting with all gates open. The maximum discharge with the reservoir at the top of the main dam was estimated to be 950 c.f.s. The discharge rating curves are presented on Plate 6.

2.1.2 Municipal Water Supply Outlet

The municipal water supply outlet for the City of Conrad is incorporated into the low-level outlet described in paragraph 2.1.1. A small treatment facility is located just downstream of the dam. A small pipe (approximately 8 inches in diameter) extends from the small wet well at the outlet structure of the low-level outlet to the treatment facility.

The two 4- by 7-foot slide gates at the outlet structure are used to pressurize the entire length of outlet conduit through the dam. This causes water to rise in the small wet well immediately upstream of the gates so the water can flow by gravity to the treatment facility. The level of the water at the outlet structure is controlled by an overflow pipe (Photo 3).

For seasonal irrigation releases, the gates at the outlet are adjusted until water spills from the overflow pipe (see Photo 3) to the stilling pool at the end of the outlet. A small (8- to 10-inch-diameter) valve at the upstream wet well allows water to enter the outlet works during the nonirrigation season so it can be withdrawn at the outlet structure for the city water system.

This type of operation, with a pressurized low-level conduit, may cause water under head to be forced out through cracks in the conduit and into the dam embankment; a piping failure of the embankment could occur. In addition, there is a potential for pressurizing the outlet conduit to substantially more than is required for the City water system. This could occur if the slide gates at the outlet structure remain shut or are not open when irrigation releases are started or increased.

2.1.3 Outlet Works, North Dam

The outlet works for Lake Frances North Dam is located through the embankment near the right abutment of the dam and discharges into a canal. The outlet works consists of three parallel cast-in-place concrete conduits, each about 70 feet long. Flow through each conduit is controlled by a slide gate at the upstream side of the conduit.

The concrete intake structure was in very poor condition, showing heavy spalling and exposed reinforcement (Photo 4). The center outlet conduit has a 5-foot diameter. One 5-foot-

wide by 4-foot-high rectangular conduit is located on each side of the circular conduit. The concrete of each conduit was in very good condition. The 5-foot-diameter conduit had about 1 foot of gravel along the bottom. The right (looking downstream) conduit had a large muskrat nest built against the gate. The left slide gate was cracked and leaking about 5 gallons per minute. The gate operator for the left slide gate had been removed for servicing. At the time of the inspection, only the gate for the center conduit was in operating condition.

According to Mr. Stokes, by the end of the irrigation season, the reservoir usually drops below the inverts of the three conduits. This allows the operators to clean any gravel or debris from the gate seats. However, this year the reservoir remained above the inverts, and the seat for the center conduit gate could not be cleaned. The flow in the center conduit could not be totally stopped because of gravel, which prevented a seal on the gate. In order to minimize this flow, the operators pushed additional gravel upstream of the gate.

The discharge rating was developed for the three conduits with the gates fully open by assuming full conduit flow and a Manning's "n" of 0.014. The maximum discharge capacity of the outlet works with the reservoir at top of dam, elevation 3822 feet NGVD, was estimated at 1,300 c.f.s. Currently, with only the center conduit operable, approximately 500 c.f.s. could be discharged with the reservoir at top of the main dam, elevation 3822 feet NGVD.

The three conduits discharge to a common stilling pool at the downstream toe of the dam. A 7-foot-radius, quarter-round concrete hood (Photo 5) extends in front of the conduits. The water exits from the bottom of the hood to a 47-foot-wide, 24-foot-long, trapezoidal concrete structure. The structure contains some silt and debris. The concrete is in good condition but shows some signs of spalling. The downstream channel is not riprapped but is neither eroding nor backcutting.

2.1.4 Freeboard

The freeboard on East Dam for the PMF (see paragraph 2.2.4) is about 0.3 foot. The crest of the North Dam is about 2.5 feet higher than that of the East Dam. The vertical distance between the low point on the main dam and the reservoir level at the time of the October 29, 1979, inspection was 13 feet. The reservoir has no spillway but is usually filled to a maximum level about 5 feet below the crest of the East Dam and 7.5 feet below the crest of the North Dam. The crest of the East Dam varies about 2.8 feet over its 700-foot length. The effective fetch for wind-generated waves on the reservoir is 1.5 miles for the East Dam and 2.8 miles for the North Dam. Wave runup on the embankment

is estimated to be 6 feet for the East Dam and 8 feet for the North Dam. The vertical distance between the crest of the East Dam and the normal reservoir level is not adequate to prevent overtopping the embankment by wind-generated waves; therefore, a 3-foot-high corrugated metal parapet wall (Photo 6) above the crest of the dam was added. The wall does not accomplish its full purpose because of gaps in the wall. The vertical distance between the crest of the North Dam and the normal reservoir level is barely adequate to prevent overtopping the embankment by the waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental in nature, characterized by warm summers and cold winters. The nearest climatological station (elevation 3805) is at Valier on the eastern shore of Lake Frances. Mean annual precipitation at the station is 13 inches, with 57 percent falling in May through July. Mean January precipitation is 0.30 inches and mean July precipitation is 3.69 inches. Mean annual temperature at Valier is 42.5 degrees Fahrenheit (F); mean January temperature is 18.6 degrees F, and mean July temperature is 65.7 degrees F. Summer temperatures can exceed 100 degrees F, and winter temperatures can dip well below 0 degrees F. Winters have few extended cold spells, and periods of warm, windy "chinook" weather occur between cold spells.

The drainage basin area for Lake Frances Dams is 21.5 square miles; 8.3 square miles is lake area, and 13.2 square miles is land area. Basin elevations vary from 3820 feet to 4000 feet and consist mainly of rolling grassland. The lake is an off-channel storage area and is filled by canal diversion. The Pondera County Canal and Reservoir Company reads the lake elevation and determines the storage volume at 1-month intervals.

According to Mr. Stokes, the reservoir has experienced no problem handling historical floods. However, there was some concern in 1964 when a flood, combined with an upstream dam break, caused the canal headworks for the feeder canal to be washed out, which prevented flow into Lake Frances from being shut off. The maximum reservoir level of 3818.3 feet NGVD (3815.9 feet Lake Frances Datum) occurred in June 1953. A storage of 111,400 acre-feet corresponds to this elevation. The Pondera County Canal and Reservoir Company usually considers the lake full at elevation 3817.1 feet NGVD (3814.7 feet Lake Frances Datum), which corresponds to a storage of 105,000 acre-feet.

2.2.2 Reservoir Storage and Outlet Discharge

The reservoir has a surface area of 5,300 acres and storage of 105,000 acre-feet at normal maximum, elevation 3817.1 feet NGVD (3814.7 feet Lake Frances datum). Approximately 28,000 acre-feet of surcharge storage is available in the reservoir between normal maximum pool and dam crest. The outlet works at the main dam, with the reservoir at the dam crest, can discharge 950 c.f.s., about 80 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The procedure contained in the U.S. Weather Bureau's Technical Paper 38 (Ref. 4) was used to compute the probable maximum precipitation (PMP). This storm produces 10.2 inches in 6 hours and 15.8 inches in 24 hours. The 72-hour precipitation was estimated to be 18.1 inches, which is 115 percent of the 24-hour precipitation value.

The reservoir was assumed to be at normal maximum level (105,000 acre-feet) prior to the PMF. The PMF was preceded by precipitation equivalent to the 6.41-inch, June 1948 event. Frozen ground and no infiltration losses were assumed, and the canal inflow and the outlet works were assumed to be closed during this antecedent storm. The antecedent storm causes the reservoir volume to increase to 112,350 acre-feet. All the outlet works were assumed to be opened at the end of the antecedent storm. A base flow of 1,000 c.f.s. was used for the entire 72-hour PMP to account for canal inflow. This inflow could be the result of a failure of the headworks (as in 1964) or from interception of runoff outside the Lake Frances drainage. The estimate of the PMP with canal base flow produced a flood with a volume of 22,500 acre-feet.

2.2.4 Flood Routing

The reservoir storage was assumed to be at 105,000 acre-feet (elevation 3817.1) at the beginning of the antecedent flood. The antecedent flood and the PMF volumes (including canal inflow) were added to the 105,000 acre-feet starting reservoir. East Dam outlet works discharge was subtracted during the PMF. It was found that the project can control the PMF and antecedent flood, as described above, with 0.3 of a foot of freeboard remaining on the East Dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankments

East Dam

The 57-foot-high, straight-axis embankment is 760 feet long and has a crest width of 20 feet (Plate 5). The upstream slope is 1 V on 3 H from the base to about elevation 3811 and 1 V on 2 H for the upper portion. The downstream slope is 1 V on 3 H from the base to an 18-foot-wide bench at elevation 3804 and 1 V on 2 H for the upper portion.

Visual inspection showed the exposed downstream embankment slope materials were fine sandy silt with gravel, covered by grass and small brush (Photo 7). The embankment material would quickly erode and rapidly fail if the dam were overtopped. The upstream slope (Photo 8) is adequately protected from wave erosion by a blanket of subrounded gravel riprap estimated to be 18 inches thick, placed directly on the sandy silt embankment. Some minor wave erosion has occurred near the abutments, outside the limits of the riprap.

A 150-foot-long longitudinal crack approximately 15 feet above the downstream toe and about 3 inches wide is shown on Plate 5 and Photo 9. A representative of the dam owners present during the inspection indicated that this crack developed when the waterline to the missile base (shown on Plate 5) was installed in 1975. It is our judgment that the crack may have resulted from inadequate compaction of backfill and does not affect embankment stability. However, this condition needs to be investigated and corrected. No movement of the downstream toe was detected. However, on the right side of the outlet structure and adjacent to the stilling pool (Photo 10), erosion and sloughing had taken place. This condition may not affect overall embankment stability; however, action should be taken to prevent further erosion. No other significant erosion, irregularities, slumps, or cracks were found on the dam crest or slopes.

North Dam

The 20-foot-high embankment is approximately 6,000 feet long and has a crest width of 15 feet. The upstream slope is 1 V on 2 H and the downstream slope is 1 V on 1.5 H. The dam crest also serves as an access road along the northern edge of Lake Frances.

A visual inspection found embankment materials to be a sandy silt with some gravel. The embankment material would quickly erode and rapidly fail if the dam were overtopped. The upstream slope above the normal waterline (Photo 11) and the downstream slope (Photo 12) were covered with a thick layer of grass with some brush and trees. Some gravels had been

placed on the upstream slope, but this protection is not sufficient to prevent wave erosion along much of the dam length. In some areas, erosion has left the upstream slope 1 V on 1 H. Rubble has been placed on both sides of the inlet structure wing walls for wave protection. The wave erosion is significant in some areas and should be corrected; however, because of the width of the dam at normal water levels, the condition at this time does not seriously affect embankment stability. No other significant erosion, irregularity, slumps, or cracks were found on the dam crest or slopes.

2.3.2 Foundation Conditions, Seepage, and Drainage

East Dam

Both abutments of the dam are terrace deposits underlain by bedded sandstone. The plans do not indicate how the cutoff was obtained between the embankment and the abutments or how the original ground surface was prepared. Under the main embankment, drawings show a sheet pile cutoff wall was driven through foundation materials to rock (Plate 8). Extending up through the embankment, being founded on the sheet pile wall, a cyclopeon concrete (concrete with large aggregate) cutoff wall was constructed with the dimensions shown on Plate 8.

During the inspection, seepage was observed flowing from 8- and 12-inch pipes and the stilling pool slope in the left abutment and from the stilling pool slopes on the right abutment. All the seepage areas are downstream from the embankment toe (see Plate 2). The total seepage quantity is about 25 to 30 gpm and flowing clear.

The 8-inch and 12-inch pipes at the left abutment were part of a scheme to protect the left side of the dam and abutment from a serious seepage problem that developed in 1920. The proposed plan is shown on Plate 9. The observed seepage is causing stilling pool slope erosion (Photo 10) but does not appear to be adversely affecting the embankment. During future periods of high reservoir levels, however, this seepage may be greater and could cause erosion of the embankment toe on the right side of the outlet works structure.

The dam embankment contains no internal drainage system. Eleven piezometers have been installed, three on the dam crest and eight on the downstream slope. Several piezometers were plugged, but readings taken during the inspection agreed closely with those taken in the 1973 inspection report (Ref. 3) with nearly the same reservoir level. The readings show the phreatic surface in the embankment at a level 5 feet above the outlet conduit at dam centerline.

North Dam

The dam is presumed founded on terrace deposit throughout its length. A description on a 1920 plan of the section shows that a cutoff trench was carried through "gravels" into "yellow clay" and that the original ground was scarified under the embankment (Plate 7). Representatives of the project did not know whether or not this cutoff trench was constructed.

During the inspection, seepage and signs of past seepage were observed along much of the downstream toe. Most of the downstream area is heavily overgrown with grass and brush, but no serious erosion was observed nor any piping of fine-grained materials.

The dam embankment contains no known internal drains and no piezometers.

2.3.3 Stability

East Dam

No stability analysis is on file as is required by the recommended guidelines (Ref. 1) for high hazard structures. Based on a review of available information, the embankment stability may be in conformance with the recommended guidelines. With the lack of material strength data and classification and detailed description of construction procedures, and piezometer readings at the full reservoir pool, the embankment stability cannot be evaluated.

The present condition and operation of the outlet conduit could possibly cause an embankment failure by piping of the fine-grained materials if water is forced out of observed cracks. It is our judgment that the present condition does not represent an emergency situation, but steps should be taken immediately to bring the outlet works into conformance with inspection guidelines.

North Dam

No stability analysis of the dam embankment is on file. Considering the excess freeboard at the North Dam (2.5 feet above the East Dam) that results in a wide embankment section at the normal reservoir level, the dam may be in conformance with the recommended guidelines. However, due to the lack of strength data, material and classification test data, and piezometers, the embankment stability cannot be evaluated.

2.4 PROJECT OPERATION AND MAINTENANCE

Lake Frances Dams are owned and operated by the Pondera County Canal and Reservoir Company. There is no formal

operation and maintenance program for the facility. Information on operations and maintenance was obtained through discussions with Mr. Stokes, Manager of the Pondera County Canal and Reservoir Company.

2.4.1 Dam

Maintenance of the dam is performed as required. The company makes annual inspections of the outlet works at the East Dam. The project appeared to be fairly well maintained, but some items, such as the outlet conduits at the East Dam and the intake structure for the outlet works at the North Dam, require extensive maintenance.

2.4.2 Reservoir

The reservoir is used primarily for storage of irrigation water, but the reservoir is also used for municipal water supply. The East (main) Dam is visited about twice a day by personnel of the company. The Pondera County Canal and Reservoir Company office is in Valier, about 15 minutes from the East Dam and about 10 minutes from the North Dam. The reservoir is filled by canal diversion and releases are made through the East Dam and North Dam outlet works as needed for irrigation. Usually, all releases from the East Dam are made through the lower conduit. The gate valve for the upper conduit is opened only if more release is needed when the gate valve for the lower conduit is fully open. The gate valve for the upper conduit has not been open since 1975 when it was used to pass flood flows.

For any given irrigation release at the East Dam, the two slide gates at the outlet structure are adjusted until water spills from the overflow pipe. This allows water to flow to the City of Conrad's water treatment facility just downstream of the dam. During the nonirrigation season, a small (8- to 10-inch-diameter) valve is opened, which allows water to enter the outlet works. The two slide gates at the outlet are again adjusted so water can flow to the treatment facility.

The reservoir normally fluctuates less than 5 feet in a year with many years showing only a 1- or 2-foot change in reservoir water surface. There is no spillway for the project, but the operators try to fill the reservoir to no more than elevation 3817.1 feet NGVD (3814.7 feet Lake Frances Datum). The operators make monthly readings of lake elevations. They also make elevation readings on a bench mark on the dam crest and a bench mark on the upstream control tower to check for any relative movement.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

Chapter 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, East Dam of the Lake Frances project is large in size with a high downstream hazard potential rating. North Dam of the Lake Frances project is also large in size, and the downstream hazard potential rating is significant. The guidelines recommend that a project with the above classification be capable of safely handling 100 percent of the PMF. The project is capable of controlling the PMF estimated for this report without overtopping the dam, provided that the outlet works safely function to full capacity. However, the present condition of the outlet conduit could cause an embankment failure by piping of fine grain material.

No stability analysis of the East dam embankment is on file. Based on a review of the available plans, the embankment stability may be in conformance with the recommended guideline; however, stability evaluation is not possible without soil strength data and water level information at high pool.

No stability analysis of the North dam embankment is on file. Considering the excess freeboard at the North Dam that results in a wide embankment section at the normal reservoir level, the dam may be in conformance with the recommended guidelines; however, stability cannot be evaluated, because information on soil strength and water levels in the embankment are not available.

3.1.2 Embankment Dam

East Dam

A visual inspection found a 150-foot-long longitudinal crack on the lower portion of the downstream slope. Reports are that the crack developed in 1975 during placement of a waterline across the downstream slope.

Seepage was observed in several areas at the downstream toe and along slopes of the stilling pool; it was estimated to total 25 to 30 gpm. This seepage was causing some erosion right of the outlet works structure.

Piezometers that are operational showed that water levels in the downstream embankment zone are low (Refer to paragraph 2.3.2).

The upstream and downstream slopes were uniform with no irregularities or slumps. The downstream slope supports a covering of grass and small brush. Subrounded gravel riprap adequately protects upstream slopes against erosion. The vertical distance between the crest of the dam and the normal reservoir level is not adequate to prevent overtopping the embankment by wind-generated waves; therefore, a 3-foot-high corrugated metal wall was installed and is effective except where there are gaps in the wall.

North Dam

A brief visual inspection of the dam revealed neither longitudinal or transverse cracking nor any embankment irregularity or sloughing. Seepage and signs of past seepage were observed along the dam's length, throughout the downstream toe. Some gravels existed on the upstream slope, but this protection was not sufficient to prevent wave erosion along much of the upstream slope area. Rubble has been placed on both sides of the inlet structure for wave protection.

3.1.3 Discharge and Reservoir Capacity

The reservoir has a surface area of 5,300 acres and storage of 105,000 acre-feet at normal maximum elevation, 3817.1 feet NGVD (3814.7 feet Lake Frances datum). Approximately 28,000 acre-feet of surcharge storage is available in the reservoir between normal maximum pool and the dam crest. The outlet works at the main dam, with the reservoir at the dam crest and assuming full discharge capability, can discharge 950 c.f.s., about 80 acre-feet per hour.

3.1.4 Outlet Works

The outlet works at the East Dam contains cracks up to 3 inches wide. Several locations have been repaired with steel sleeves. The conduits generally appeared in rough condition with many abrupt changes in the flow sections. Cavitation has damaged the concrete and the gate housing immediately downstream of the lower gate valve at the upstream wet well. These areas have not reached the critical stage but do require maintenance. Neither the upper nor lower gate valves have air vents. The outlet conduits are almost constantly pressurized because of operation for the City of Conrad's water supply. This could cause water to be forced out through cracks in the conduit, which may cause a piping failure of the embankment. The maximum discharge capacity of the outlet works with all gates open and with the reservoir at the crest of the East Dam was estimated to be 950 c.f.s.

The outlet works for the North Dam is in poor condition. Only one of the three slide gates is in operating condition. The intake structure concrete is heavily spalled with exposed reinforcement. The slide gate for the center conduit could

not be fully seated at the end of this irrigation season because of gravel in the seat groove, so additional gravel was pushed in front of the intake structure to minimize the flow under the gate. The discharge capacity with only the center gate in operating condition was estimated to be 500 c.f.s. If all gates were in operating condition, the discharge capacity may be 1,300 c.f.s.

3.1.5 Operation and Maintenance

The Pondera County Canal and Reservoir Company has no formal operations and maintenance plan for the Lake Frances project. Maintenance is performed as required. Yearly inspections are made of the outlet works at the East Dam. Releases from the reservoir are made as needed for irrigation. The outlet conduits are pressurized and water is drawn for the City of Conrad's water supply. A potential exists for pressurizing the conduits more than is required for the City water system. This could occur if the slide gates at the outlet structure remain shut or are not sufficiently open when irrigation releases are started or increased. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, while preserving this existing flood protection.

The findings suggest that high priority be given to the following recommendations:

Both East Dam and North Dam

1. Immediately develop, implement, and periodically check an emergency plan for alerting downstream residents in case of impending dam overtopping or structural failure.

2. Evaluate reliability of canal headworks system to ensure that flow from canal into reservoir can be shut off at all times and for all flow conditions. Include a plan for breaching of the canal to prevent flood flow from entering Lake Frances during an emergency high reservoir situation.

East Dam

3. Reevaluate the present water withdrawal system for the City of Conrad, which now requires pressurizing the outlet conduits. Consider developing an independent system which would then permit removal of the two slide gates at the outlet structure similar to the original construction.

4. Investigate and repair all cracks in the outlet conduits, or fit conduits with liners, grouting all voids found outside the conduit and between liners. Provide smooth transitions at each change in conduit cross section.

5. Repair cavitation damage at the lower gate valve at the upstream wet-well tower.

6. Provide air vents at all operating gates except at outlet.

7. Close gaps in corrugated metal parapet wall to improve protection against wave attack.

8. Operate all gates through their full operating range at least annually.

9. Provide protection from erosion and loss of fines from the embankment toe in areas adjacent to the outlet structure.

   Inspect the stilling pool and area downstream of outlet structure for erosional damage (undercutting). Repair as required.

10. Repair crack in downstream embankment slope and install instrumentation to detect any future movements.

11. Rehabilitate all piezometers. Read piezometers several times a year especially during reservoir filling and full storage, referencing lake levels, and developing a permanent record of readings.

North Dam

12. Repair North Dam intake structure concrete.

13. Remove all trees from the upstream and downstream slopes and backfill with embankment material.

14. Reshape upstream slope to 1 V on 2 H where erosion has oversteepened slope, and provide wave protection using properly sized granular material bedding and riprap.

Both East and North Dams

15. Conduct embankment stability analyses using data from field investigations and laboratory tests, as appropriate. Design and implement any dam modifications to bring stability into conformance with recommended guidelines. Stability studies and modifications should be performed by an experienced geotechnical engineer.

16. Make inspections of the dams during the next spring and summer periods at full reservoir levels. Reference location and estimate flows of any seepage. Periodic inspections of the dams should be conducted at least once every 3 years by engineers experienced in dam design and construction.

17. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.
2. Richard D. Eckerlin, U.S. Army Corps of Engineers, Memorandum on Lake Frances Dams Geology Inspection, February 1980.

3. U.S. Army Corps of Engineers, Report on Visual Inspection of East Dam--Lake Frances, February 1973.

4. U.S. Weather Bureau, Technical Paper 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Washington, D.C., 1960.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING
STATE OF MONTANA
(406) 449-2872
HELENA, MONTANA 59601

September 8, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: CH2M/Hill Dam Safety Inspection Report on the Lake Frances East Dam (MT-1125) and the Lake Frances North Dam (MT-1484).

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it safisfies the criteria of the Phase I report. We offer the following comments:

There was no mention made of the muskrat nest on the right side of the outlet works at the East Dam. The potential hazards of nesting muskrats in the embankment should be discussed. There should be recommendations made to dispose of the muskrats at the East Dam and the North Dam.

Enclosed are copies of two reports to the Carey Land Act Board dated April 15, 1930 and September 20, 1949, which give some of the construction history and problems associated with the project.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment of the final draft on the Lake Frances Dams.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief Engineering Bureau
(406) 449-2864

RB/AT/lj
Enclosure

"AN EQUAL OPPORTUNITY EMPLOYER"

PONDERA COUNTY CANAL AND RESERVOIR COMPANY
AN ORGANIZATION OF WATER USERS ON THE VALIER PROJECT
Box 245
VALIER, MONTANA 59486

August 18, 1980

Mr. R.P. Sellevold, P.E.
Department of the Army
Seattle District, Corp of Engineers
Seattle, Washington 98124

Dear Mr. Sellevold:

The Board of Directors of the Pondera County Canal and Reservoir Company at their August 5, 1980 regular meeting reviewed the inspection report on Lake Frances Dams which was sent by your office. The Directors stated they would welcome any comments or information as how to remedy the problems. Also they would prefer an alternative route for the City of Conrad water supply line that goes through the dam.

Sincerely Yours,

Fay Stokes

Fay Stokes, Project Manager

STATE ENGINEER'S OFFICE

Helena, Montana

September 30, 1949

Carey Land Act Board

Helena, Montana

Gentlemen:

Attached hereto is an engineering report on the physical condition of the Valier Carey Land Act Project in compliance with an order of the Board.

Field work was done and the detailed report prepared by Mr. Oscar Moberg. The attached is largely briefed from his findings. The report is on file in the State Engineer's Office where it may be inspected for further details.

The project consists of two storage reservoirs--Birch Creek of 30,000 and Lake Francis of 112,000 acre feet, three diversion dams, about 500 miles of canals and laterals, several thousand structures of various kinds, and a 78" inverted siphon nearly 5,000 feet long.

Contract documents are not too detailed in most cases, which makes it very difficult to determine whether or not an item of work has been completed according to contract. I have not attempted an interpretation of the legal obligations of the construction company according to the contracts. Under customary practice whenever a project of any kind is built under contract, regardless of the length of time it takes to complete the work, the project should be in first-class condition at the time it is turned over to the owner and the contract discharged.

It has been the intent herein to point out conditions that should be remedied to provide for safety, as well as reducing the operation and maintenance costs to a minimum. Briefly these items consist of:

1. Raising Swift Dam and installing emergency gates;
2. Repairing Lake Frances Dam, outlet tunnel, gates, and dike;
3. Remodeling the two diversion weirs--Birch and Dupuyer Creeks;
4. Rebuilding the inverted siphon across Big Flat Coulee;
5. Installing drops and checks in many canals to reduce the velocities thereby saving canal erosion and the depositing of silt in lower reaches where velocities are normal;
6. Repairing and/or rebuilding many of the structures;
7. Cleaning many canals and laterals of cattails, willows, and silt;
8. Installing drains to protect adjacent lands that have become seeped;

Your attention is called to the matter of water rights described herein.

It is impossible at the present time to place an estimate on the cost of rehabilitating the project as outlined. (See text).

Attached sketch map shows the reservoirs and only the main canals.

Respectfully submitted,

Fred E Buck

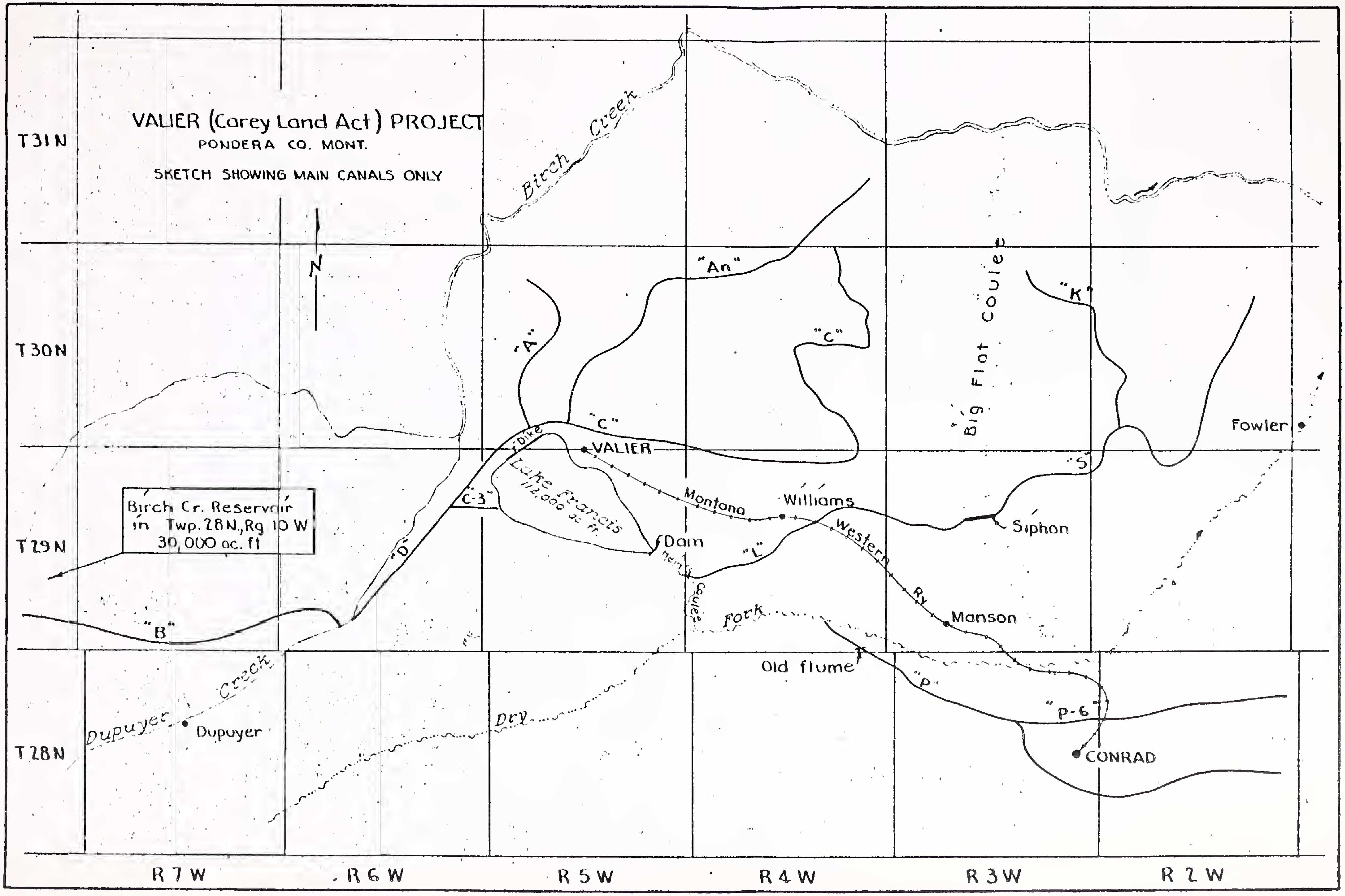
STATE ENGINEER

FEB:mep

VALIER (Carey Land Act) PROJECT

PONDERA CO. MONT.

SKETCH SHOWING MAIN CANALS ONLY



ENGINEERING REPORT ON THE VALIER (CAREY LAND ACT) PROJECT

September 30, 1949

At a meeting of the Carey Land Act Board held September 13, 1947, the following motions were made, seconded, and unanimously carried:

> "That the State Engineer be instructed to examine the entire Valier Project, estimate what work remains to be done, and the cost thereof to complete the project."
>
> "That the State Engineer be empowered to employ the necessary engineering assistance to carry out the investigation providing funds are available for the purpose from the Carey Land Act Fund."

At a meeting of said Board held March 30, 1948, the following minute entry appears:

> "Mr. Buck reported that he had employed Mr. Oscar Moberg to assist in carrying out the wishes of the Board as set forth in the minutes of September 13, 1947."

Mr. Moberg began work January 15, 1948, and has just completed the field inspection and report.

Construction work began on this project by the Conrad Land and Water Company about 40 years ago. The original contract, which was between the construction company and the Carey Land Act Board, has been changed and amended numerous times. (See Appendix I for brief summary of changes made in the contract.)

Information on file is not very definite in regard to the details of the plans and specifications that were to be followed in constructing the project. The work apparently has been done by piecemeal and approval of the various units of construction has been either given or implied from time to time as the construction work progressed. Under such circumstances, it is difficult to adjudge with any degree of certainty whether or not any particular structure has been completed according to contract.

The Valier Company in the meantime has been maintaining and operating the project under the terms of a contract signed each year with the Pondera County Canal and Reservoir Company which is the company that will eventually take over the project.

There are a great many defects in the canals and structures that should be remedied to reduce the cost of operating the system. It is very evident that these conditions have been the result of various contingencies. Some structures are old, worn out, have outlived their usefulness, and should be rebuilt. Improper or deferred maintenance has been the cause of the poor physical condition of many structures. A good deal of this deferred maintenance undoubtedly accumulated during the recent war period when it was difficult to obtain labor and materials. Several of the canals in various places have too much grade, which causes bank erosion due to excess velocities, and the deposit of silt in lower stretches where the velocities are much slower. These conditions increase the maintenance costs and should be corrected.

Although this project has been under construction for the last 40 years under contract with the Carey Land Act Board, it has never been turned over to the water users as a completed contract and the construction company released from its obligations.

Under normal conditions, a project of any character built by a contractor shall be in first-class condition in every respect at the time it is turned over to the owner. If a contractor has taken an overdue length of time to complete his work and in the meantime some of the units have deteriorated, he is obligated according to customary practice to repair these units in first-class condition before turning over the project and being released from the contract.

It is impossible at this time to estimate the cost of the repair that should be undertaken. Costs are not stable and the character of the repairs and the method of accomplishing them will greatly affect the costs. In many instances, detailed surveys will need to be made and construction plans drawn before a determination can be made of the best type of repairs to be installed. Until this is done, there is no way of estimating the cost of such units. Again, there will be quite a variance in the cost depending upon whether the work is all let in one contract or whether it is done by the regular operating crew over a longer period of time.

Mr. Moberg's final report is a voluminous text of some 160 typewritten pages, and will not be attached to and presented in its entirety as part of this report. Wherever quotations appear below, they will be taken from the Moberg Report unless otherwise designated.

The major items of the Valier Irrigation Project consist of two storage reservoirs, two diversion dams, three major diversion canals, a large inverted siphon, about 500 miles of secondary canals and laterals, several hundred drops and chutes, and thousands of small structures.

SWIFT DAM

Mr. Moberg's conclusions has this to say about the condition of Swift Dam:

> "In 1917, Valve No. 4 (farthest upstream) was cracked and removed; in 1923 Valve No. 1 (farthest downstream) was reported cracked and removed and a blind flange placed over the opening. In 1948 there were valves in the first three positions and a blind flange in place of No. 4 Valve. Their operation was not observed, however, all of them can be considered as well past their useful life. There is no emergency control and in the event any valve is damaged it is necessary to drain the reservoir to repair it. If all valves were put out of commission it would be a difficult and expensive task to repair them.
>
> "Due to improperly designed spillway and also to the excess settlement of the rock fill, a spillway could not handle the flood flow discharge that might be reasonably expected here and the dam would be overtopped. The top of the dam has settled 3.2 feet to date (1948)."

In the modern practice of constructing dams of this size, it certainly is not ethical to install a single valve in each operating tube without installing an emergency valve that can be shut down in case repairs are necessary.

About two years ago the Swift Reservoir had to be drained in order to repack the present valves. If an emergency valve had been installed above the operating valves, this repair could have been done without draining the reservoir.

From the standpoint of available water supply, this condition is not too serious unless an emergency should arise after the high water season has passed or during the irrigation months. An emergency valve should be installed above each operating valve to prevent the necessity of ever draining the reservoir during the period when the stored water is needed for irrigation.

Additional fill should be placed on the top of the dam to bring its elevation up to where it was intended to be at the time of completing the dam.

BIRCH CREEK DIVERSION

> "The field inspection in 1948 found the area immediately upstream from the weir (Birch Creek Diversion) to be completely filled in with silt, gravel and debris for a distance of at least 1000 feet above the weir causing backwater and flooding for a considerable distance upstream. There is also a danger here that in time of flooding the stream will be diverted over against the dike and destroy it. Due also to the clogged condition of the approach channel to the canal gates, it would be impossible to divert the amount of water that is required to operate the "B" canal at capacity without wasting a considerable amount over the weir.
>
> "The weir, as is, could handle a flood of about 12,000 second feet, which is about 2½ times the maximum on record. A flood of 20,000 second feet, which can be expected, on the basis of a study of the rainstorm of June 16, 17, 1948, would top the dike and gates by two feet. At least four feet should be taken off the top of the weir and the canal gates lowered a corresponding amount or more.
>
> "The accumulation of the material in front of the weir and gates has rendered the weir and gates completely useless as a diversion structure. The position of the canal gates on a line that is practically at a right angle to the thread of the current also permits a considerable amount of the gravel and silt to enter the canal. Practically all of these difficulties could have been avoided by placing the gates on a line parallel to the thread of the current and also by providing a sluiceway in the weir with an opening several times larger than at present."

A serious operating condition exists at the present time at this diversion weir. There is no way to flush out the sand and gravel that is being constantly deposited in front of the headgates of the "B" Canal nor to prevent the sand and gravel from entering the canal itself. The creek channel has been completely filled in to the top of the weir crest so that it would be impossible to fill the "B" Canal with water to capacity without wasting considerable over the crest of the weir. This condition should be remedied. Perhaps the best solution is by removing a section of the right end of the weir and replacing it with sluice gates. This will partly solve the problem of being able to fill the "B" Canal without wasting too much water over the weir. At the same time the improvement will alleviate the necessity of dredging out the sand and gravel periodically from in front of the canal gates and along the "B" canal and thus reduce the operating costs.

BIRCH CREEK OR "B" CANAL

According to the contract this canal should have a capacity of 700 second feet. It is 14.2 miles long and has a total drop of 267.6 feet.

> "This canal is an enlargement of an old canal built about the year 1900, and follows the same grade and alinement. The original canal has a fall of 0.1 foot per 100 feet. The present canal is apparently controlled by this grade for the first 1½ miles from the headgate, then it falls into Cartwright Coulee through a vertical distance of 117' in 6000' horizontally. From Cartwright Coulee it is apparently on grade for a distance of nearly 10 miles to where it drops 61' in a distance of about 1½ miles into Dupuyer Creek.
>
> "The excess gradient creates velocities in the water that are greater than the materials in which the canal is constructed can withstand. Scouring and erosion of the sides and bottom of the canal has been excessive and has created many weak and dangerous places. Not more than 150 to 200 second feet of water could be safely carried in this canal at the present time. Efforts have been made to stop this erosion by placing timber, concrete and rock structures at various places along the canal and the use of rock riprap and various types of bank protection. These measures have been completely ineffective and in many cases have actually aggravated the situation. The eroded material from the canal has been carried into the distribution system and also into Lake Frances reservoir. Excessive leakage from the canal has seeped thousands of acres of farm and pasture land and rendered it almost completely unproductive."

The Birch Creek Canal is in very poor physical condition. The grades are too steep resulting in bank erosion from the high velocities. There are not sufficient drops and some of the drops have been washed outentirely. Gravel that has washed into the head of the canal from Birch Creek should be cleaned out. If this canal is rehabilitated and put in proper operating condition it will materially reduce the yearly operation and maintenance costs. A profile should be run along the entire length of the canal and sufficient engineering data secured to design proper drops to retard the high velocities.

Until such a survey is made, it is impossible to tell where the drops should be placed, how high they should be, and how many would be required. This study should be made for the section of canal from its headworks to where it drops into Heinz Coulee and a second section from the diversion out of Heinz Coulæ to the outlet in Dupuyer Creek.

While the water has eroded a deep canyon through Heinz Coulee, the channel bed is now pretty well stabilized. Soil along adjacent banks is thin and of poor quality, so that any further erosion of the banks through Heinz Coulee will not be too destructive to adjacent lands. This erosion, however, does create a maintenance problem along the canal after it diverts from Heinz Coulee.

If the velocities in the "B" canal are properly checked up by the installation of drops, it will eliminate the necessity of building revertments along the banks to prevent erosion, such as poles, wire, brush, lumber, etc. Also it will eliminate the necessity of much cleaning of canals in the lower reaches of the project.

DUPUYER CREEK DIVERSION WORKS AND "D" CANAL

> "The structure is supposed to be capable of diverting up to 900 second feet into the "D" canal, however, the situation here is very much the same as at the Birch Creek Diversion works in that, because of the position of the gates and the inadequacy of the sluiceway, the channel upstream has become filled with sand, gravel, silt, and debris and this quantity of water could not go through the gates without wasting a considerable amount over the weir. A considerable amount of material is also carried by the stream into the canal.
>
> "Like the "B" Canal, its gradient is entirely too steep and not more than about 200 second feet could be safely transported."

This canal is 3.2 miles long and required under the contract to have a carrying capacity of 900 second feet. A large part of the material carried by the stream enters the canal instead of going through the sluiceway and on down Dupuyer Creek. Sluicegates should be placed at the right end of the weir so that silt and debris carried by the creek can be flushed on down the creek instead of being sent down the canal. Flashboards should be provided along the balance of the weir so that the entire water supply can be diverted down the canal in case it is needed and thus prevent wastage down Dupuyer Creek.

"C-3" CANAL

> "This canal is a continuation of the 'Intake Canal' and extends from the end of the "D" Canal, in an easterly direction a distance of two miles, to Lake Frances Reservoir. Its required capacity is 900 second feet.
>
> "In the first 4,150' this canal has a fall of 23.2' or an average grade of 0.6' per 100' and the last 6,200' the total fall is 23' to the surface of a full reservoir. This gradient develops velocities in the water of over 7' per second which is even too fast for canals in rock sections. Considerable erosion has occurred and in the last 6,000' the canal has meandered considerably cutting out its banks at bends and has destroyed a considerable amount of good farm land and carried a considerable amount of silt into the reservoir.
>
> "The concrete in the structure (diversion structure from the "D" Canal) especially below water surface, is badly worn and the reinforcing steel is exposed. The headwall above the openings for the "C" Canal is cracked. The "C-3" Canal just below the right portion of the structure has eroded severely and what appears to be concrete paving has been placed in the bottom, about 18 inches to 24 inches lower than the floor of the structure and extending about 25 feet downstream at the end of which there is an additional drop of two feet or more. This paving appears to be worn considerably."

The structure (concrete chute at Sta. 41 / 50) was built to stop the erosion of the right bank on the outside of a sharp curve below the structure.

> "The field inspection on September 15 and November 5, 1948, shows that the chute apparently has failed to accomplish the purpose for which it was intended. The right side shows erosion both above and below the structure and some plank anchored to pipe driven into the bottom of the canal to protect the right bank around the curve has deteriorated to where it no longer is effective. The cutoff wall at the downstream

> end of the chute on the right side is uncovered.
>
> "From the concrete chute to the reservoir the canal has meandered considerably and is at present in about a four foot cut. It is my understanding that sufficient right of way has been purchased to take care of this meandering. This has not been checked, however, it does not seem reasonable or sensible to permit the canal to erode and wash away good farm land just because it belongs to the company nor does it seem sensible to allow the sediment to be carried into the reservoir."

The concrete diversion works and chute should be repaired. Drops should be placed in this canal to retard the high velocities and thus prevent future maintenance costs.

LAKE FRANCIS DAM AND DIKE

When the dam was first built creating Lake Frances, the storage capacity was believed to be 170,000 acre feet. Work on the dam was originally carried on in 1908 and completed early in 1909. "In 1910 detailed survey of Lake Frances was made under the direction of the State Engineer and the capacity . . . determined to be 112,000 acre feet at Elev. 3816." The dam is an "earthfill with a concrete corewall and steel sheet piling cutoff extending from bottom of corewall to bedrock, about 225 feet across the valley bottom. The top of the dam is 20 feet wide, about 750 feet long, 42 feet above streambed, 98 feet above bedrock." From the records construction of this dam caused a great deal of trouble. Mr. John W. Wade, State Engineer, addressed a letter to the Carey Land Act Board under date of August 30, 1909, (see Appendix II) calling attention to a failure in the gate tower. On October 27, 1911, Mr. A. W. Mahon, State Engineer, addressed a letter to the Carey Land Act Board calling attention to the serious condition of the dam. (See Appendix III). Under date of February 21, 1912, Mr. Thaddeus Merriman, a noted authority on hydraulics, addressed a letter to the Chief Engineer, Ford, Bacon and Davis, New York City, calling attention to the condition of the dam and the necessary repairs needed. (See Appendix IV). Although numerous repairs have been made on the dam, tunnels and gates, the structure is still not in first-class condition. The outlet tunnel consists of a double-barreled construction resting on a wooden pile foundation. The gate tower is built immediately behind thecorewall and made an integral part of the corewall. After the dam was built, the outlet tunnel and gate tower settled due to having insufficient foundation which caused both the tunnel and tower to crack and leak badly. The tower was repaired by placing an inside liner of concrete which added still more weight to be carried by the insufficient pile foundation. Later on, two new gates were placed in the gate tower to be used as emergency gates which added still more weight to the unstable foundation. "When this tower is used to regulate the discharge from the reservoir, water stands in the tower at the same elevation as in the reservoir. With the full reservoir this adds another 200 tons to the total load."

The fifth Biennial Report of the State Engineer 1911-1912 had this to say about the structure:

> "The only interesting feature (the Lake Frances Dam) being the ill-advised plan of its original construction. A heavy double-barrel outlet tunnel was built through this structure along the original water course with quicksand underneath and insufficient pile support to hold it in position, when it could just as well have been placed along the side of the hill with a sandstone foundation."

There is considerable seepage around the lower toe of the dam especially on the north side. Some of this seepage is gathered in a collection chamber a short distance below the dam and diverted through a pipe line to the city of Conrad for its water supply.

Mr. Merriman after his examination states that the concrete in the bottom of the corewall was undoubtedly poured in water which caused a segregation of the cement and aggregates which resulted in a poor piece of concrete along the foundation of the corewall. This seepage may be coming through the base of the corewall or through the sandrock in the abutments.

> "I have been informed by the present caretaker for the dam that whenever the reservoir is full considerable seepage comes through the north end of the dam and the back slope of the fill becomes so saturated with water it's almost impossible to walk on it. This water probably comes through the sandrock and the north abutment or it could come through the corewall and the dam."

> "The Annual Report of the Valier Company's Operation and Maintenance Department for 1948 states that during the heavy rainstorm in June the reservoir level rose from 3815.27 on June 16 to 3816.05 on June 18 and: 'It was necessary to draw down Lake Frances and some 8,300 acre feet were sent down the Dry Fork after the peak of the flood had passed.' In view of the shortage of water in Birch and Dupuyer Creeks and lack of storage space for utilizing the water available it is unfortunate that this reservoir is not held at a higher elevation. Two or three feet additional space on top of this reservoir would make it possible to use from about 12,000 to 16,000 acre feet of water that is now wasted into the Marias River."

To aggravate this situation still further, "a very dangerous condition exists at the downstream toe of the dam at present because of the fact that the bottom of the "L" Canal which takes out of the coulee about 1/2 mile below the dam is almost 7 feet higher than the bottom of the outlet. To get water into the canal it is necessary to back water up over the outlet and toe of the dam which weakens the structure considerably by saturation. Inasmuch as the "L" Canal has too steep a gradient as will be shown later, a study should be made to the end that this canal can be lowered as much as possible and thereby lower the water table at the toe of the dam."

Work should be done on this dam to reduce the seepage as much as possible probably by pressure grouting, and drains placed along the lower toe to lead the water away and prevent saturation of the lower toe of the dam.

At the present time there is a poor arrangement of the gates in the outlet structure, the operating gates are placed in the intake end of the tunnels with the gate stems rising through the water to a platform which is connected to the dam by a catwalk. There is always a liability of the stems being damaged by ice. The emergency gates have been placed in the gate well below the operating gates. The position of these gates should be reversed. The emergency gates should always be placed above the operating gates. The emergency gate is always left open and never used only in case of an emergency and therefore is not likely to be damaged in any way. But the operating gates which are constantly in use are subject to damage and repair. When the operating gates need repairing, then water can be shut off entirely by the emergency gates which allow access to the operating gates for repairs. The way the gates are arranged at the present time if work is to be done on the operating gates it will be necessary to either drain the reservoir or send a deep-sea diver down to do the repair work under water.

The following work should be required to put this dam and facilities in good condition:

1. Pressure grout the dam to cut off seepage.

2. Place drain tile along the lower toe of the dam to alleviate saturation.

3. Plug up and abandon the present outlet works and construct a new outlet tunnel in native sandrock through either abutment of the dam.

4. Rearrange the position of the gates so that the emergency gates will be above the operating gates.

5. Lower the intake of the "L" Canal so that water will not back up and saturate the lower toe of Frances Dam.

6. Remove the present riprap from the front face of the dam, place a heavy blanket of sand and gravel and then replace the rock riprap to prevent wave action from sucking out the dirt underneath the riprap.

LAKE FRANCES DIKE

> "This structure is located approximately five miles northwest of Lake Frances Dam on the opposite side of the lake at a low spot in the rim of the reservoir where it was necessary to build an earthfill dike 6,260 feet long, top width of 10 feet and a maximum height of 22 feet. There are three concrete conduits controlled with gates extending through the fill to supply water to the lands north of Valier.
>
> "Insufficient cutoff beneath the dike and insufficient or poor material in the fill has permitted water to seep under and through the fill for nearly its entire length. There has been no drainage provided here for the foundation, and the back or outside portion of the fill is in a saturated condition which weakens the structure considerably.
>
> "The front or water slope is protected with sand and gravel and small field stone which is easily moved and washed away by wave and ice action and requires a continuous task of replacement."

The face of the dike for its full length should have a heavy layer of riprap. A drain ditch should be dug along the lower toe of the dike to drain off seepage and dry out the dike fill.

DISTRIBUTION SYSTEM

The above descriptions cover the main features of storage reservoirs and supply canals. The following covers the distribution system.

Under terms of the contract between The Valier Company and the State of Montana the following appears:

> "The party of the second part agrees to construct said irrigation system, so that water shall be available at a point not exceeding one-half mile

from any legal subdivision of the 'Carey Act Lands', purchased by the settler, and so that said system shall have a total carrying capacity sufficient for the simultaneous delivery of one cubic foot of water per second of time for every one hundred (100) acres of the lands to be irrigated from said system.

"Said party of the second part further agrees that it will construct and place in position all headgates, flumes, weirs and other devices for the control and measurement of the water in the main canals, reservoirs, and main laterals, it being understood however, that the settler, shall under the direction of the Chief Engineer of said party of the second part, build and furnish the necessary gates, and measuring devices for their own use, and that all other gates, weirs and measuring devices, in the main canals or in the main or subordinate laterals, shall be furnished and constructed by said party of the second part. Plans for measuring devices, headgates and weirs shall be approved by the State Engineer.

"All owners of water rights in said system shall be subject to such rules and regulations, based upon a plan of distribution of water in turn and by rotation, as will best protect and serve the interests of all users of water from such irrigation system. Such rules and regulations to be submitted to and approved by the Carey Land Act Board.

"B-2" LATERAL

"The lateral is in poor shape, especially so below the division point, being grown over with grass and weeds and some willows. In June 1949 it was overflowing its banks, a short distance from the headgate and just above where it enters a 30" corrugated metal pipe through the road to Dupuyer. The total fall in the "B-2" is 44.7' in 9,000' of ditch, which is excessive; however, the material is rocky and the velocity can be controlled with a concrete check and two wooden checks in the first mile, and erosive action is not in evidence. The wooden checks are nearly worn out. The 30" culvert through the road is either high at the outlet end or water has scoured out the bottom of the canal."

"B-4" LATERAL

"This lateral is about 5' deep for a short distance below the headgate. Lateral is in fair shape to a farm bridge in the NW$\frac{1}{4}$NE$\frac{1}{4}$, Sec. 21. A hole has scoured out in the bottom just below the bridge, from increased velocity due to the contracted section at the bridge. In the SW$\frac{1}{4}$, Sec. 15, livestock grazing have kept the canal and banks free of vegetation;

however, the banks are worn down and the concrete headwall for a turnout and the ends of a concrete check are nearly uncovered. Through the N½ Sec. 15 the ditch is deep, the sides and bottom have scoured considerably and the banks are sloughing. Near the north line of Sec. 15, there is an old wooden drop that is nearly all gone or broken up, apparently still in use, however. At some time in the past there were about 12 of these drops in the last three miles of this lateral; however, no evidence of any of these remain, except the one noted above. The absence of these drops no doubt accounts for the scouring and excess depth and, possibly, some of the seepage also. Eight 'modern' concrete checks have recently been placed in the lateral but none of these were built as drops and have little if any effect in controlling erosion. The main lateral has 55 feet of fall in 25,000 feet. At the division point, the main lateral is controlled with a gate and corrugated metal pipe from the end of which water has a free drop of three feet into the canal below. The last 1/4 mile of the main lateral is plowed over.

"The sub-lateral "B-4-2" contains a heavy growth of grass and weeds from where it enters Loughlin Coulee to its end. It crosses the coulee on a fill in the center of which a wooden wasteway washed out in the flood of June 16, 17, 1948. The land along the coulee is seeped and alkali. Near the south line of Sec. 3 the ditch drops about 4 feet into a draw. An old timber drop is washed out and loose field rock has been placed to check velocity. The end of the lateral is plowed under."

"C" MAIN CANAL

"The outlet(of the first drop) was originally paved with four feet of wire mesh reinforced concrete which formed a stilling pool three feet deep and 32 feet long. The paving is now (1948) badly broken up and there is no longer a pool. Loose rock and broken slabs of concrete are the only provision for checking velocity at present. The concrete flume section rests on top of the headwall for the original pipe outlet and water drops 7 feet into the canal.

"Below the outlet the canal has eroded to a bottom width of 75 feet for a distance of 100 feet. Erosion is severe for 150 feet on the right side and 300 feet on the left side on outside of a curve. There is some bank protection on the left side and gravel bars from the bottom have been pushed over against the left bank.

"There are several places (below the first drop) where willows, growing on left side of canal and on sand bars forming along the left side, throw the flow against the right side which is acouring and and sluffing in several places."

At the second drop "most of the bottom of the upper part of the lined channel is on hard sand rock from which the concrete is all broken up and gone. Exposed paving on the side slopes appear to be only two inches thick with wire mesh resting against dirt. Paving at the end of the outlet is worn out and no pool exists. The sides of the canal are severely scoured below the outlet for 100 feet on the left side, and there is a high cut bank for 200 feet on the right side." Concrete on this structure should be repaired and a stilling basin provided to prevent any further scouring of the canal banks.

The "C" Canal parallels the Lake Frances dike for about a mile. Severe seepage from either the canal or dike or both extends for at least 1/2 mile which has severely seeped and rendered useless about two or three hundred acres. For the last 600 feet the canal is within 20 to 30 feet of the toe of the dike. "The berm between, and the toe of this dike, are saturated. Presumably most of the seepage comes from the lake; however, water from the canal without any seepage from the lake would tend to saturate the dike and weaken it. The canal should be lined to alleviate this condition; however, it seems most important to stop the seepage from the lake and reinforce the downstream toe of the dike with a heavy gravel berm. A tile drain trench should also be placed near the present toe of the dike." A thorough study should be made of this situation and the serious condition remedied.

The check and turnout for the "A" Canal "is a concrete structure with vertical end walls, concrete floor and apron, and channel irons for flashboards. The right end wall is cracked and the concrete apron broken up and there is a deep hole in the bottom of the canal. The left bank is severely eroded below the check." This structure should be repaired.

The concrete check and turnout structure for the "An" Main Canal is in poor condition. The"concrete apron and wing walls down stream are badly worn. Sides of the canal have scoured severely below here."

The original concrete check and turnout for the "C-4" main lateral is badly broken up and should be repaired. "The floor of the concrete check at the center line of Sec. 34 is broken up and there are boulders placed to break up the velocity."

Near Webster Lake the lower bank has a ten-foot fill across a small draw which washed out in June 1948. The new fill leaks and the land below is wet. The canal above Webster Lake should be cleaned with a dragline for about 1/4 mile.

> "Near the center of Section 2 the canal is in fill (maximum 10 feet) for 200 feet across a low saddle on divide at the head of Winginaw Coulee. This fill leaks and water is seeping into the Coulee on both sides."

The water in the canal is checked up high so that there is less than one foot of freeboard on the fill. The lower part of "C" Canal is nearly plugged with cattails and willows.

> "There is a very small flow in the canal, yet water is backed up nearly to the top of the banks and water is leaking through the bank at the junction between the fill material and the original ground line. Water is also backing up over the top of most of the small concrete headwalls for turnouts and many of them are leaking."

> "In general the "C" Canal is in poor shape. At present below the "A" turnout there are 21 concrete checks and three old wooden checks. The original concrete checks were fairly well-built except for the floors which are all broken up. Loose field rock has been placed instead, but this is not very satisfactory and generally provides no protection for the sides. Very little reinforcing is used in these walls and practically every structure of this type on the project has a crack through the center in the bottom."

> "There is no check or outlet structure on the entire project that is properly constructed to reduce the increased velocity through the structure, to prevent erosion of the sides and bottom of the canal immediately below the structure."

"C"CANAL LATERALS

The "C-1" lateral is badly silted, at least 1/2 mile being almost all filled in.

The "C-5" lateral needs some maintenance work on the replacement of a few wooden structures.

There is a timber structure on the "C-4" lateral in Sections 26 and 27 that is in poor condition and should be repaired. A few small checks should be built to prevent erosion. Several small wooden structures on the "C-4-1" Canal are in poor condition and should be repaired. The intake to the "C-6" lateral is badly broken so that some water goes under the floor.

The joint between the concrete and wood pipe is poorly made. "The wood where exposed appears in fair shape considering its age, but is well passed its expected life. Several wood staves are pulled apart at the ends so the pipe would leak considerably if full. The ends of the concrete check at the south line of Section 26 are nearly uncovered and the wall is leaning downstream."

A good share of these laterals need cleaning as they are filled in with silt and blow dirt, and the banks infested with willows.

There are many small structures along these laterals that need repairing. In many places there should be checks and drops to prevent scouring from excessive velocity.

"A" CANAL

Along the "first two miles of the "A" Canal are several patches of heavy willows." The canal has an excess of grade, there being at least 100 feet in seven miles resulting in cutting itself deeply in many places. This condition should be corrected by the installation of checks and drops. "Near the south line of Section 17 the ground is low. The canal is in a fill section through here and in poor condition. At the south line of Section 7 the concrete check is nearly washed out" and should be repaired. "There are no structures at the end of this canal. A short distance below the junction with the waste ditch a channel 20 feet deep has been cut which gets progressively deeper until it joins the coulee which is also eroded excessively. If (this condition) is not corrected soon, this canal will continue to cut back and damage other lands."

The "A-4" lateral is in very poor condition. At the west line of Section 7 there are several drops that have been built recently which consist of a straight six-inch concrete wall placed across the canal with loose field rock placed on the downstream side. These structures may be considered only temporary unless the field rock is grouted. There should be some control of the velocity provided for the last 100 feet of this canal to prevent excessive eroding.

The wooden structures along the "A-4-1" sub-lateral are in poor condition and should be rebuilt.

"The "A-4-2" check and headgate are nearly washed out on account of insufficient cutoffs and end walls. The lateral is all choked with weeds and in general poor condition." These conditions should be remedied.

"An"CANAL

The concrete in the floors of both the inlet and outlet of the pipe drop near the intake are badly worn. The concrete floor at the check and drop of the "An-2" Canal is broken up and should be repaired. The five-mile stretch of canal above the Bullhead Drop is heavily silted, and has several stretches of heavy growth of willows. The concrete check in Section 15 is nearly closed off by blow dirt. The right side of the canal has been scoured out until the headworks for the turnout is sitting out in the middle of the canal. The check at the south side of Section 1 backs water nearly to the top of the banks and the banks are leaking. In Section 5 there is a concrete wasteway in the lower bank which does not have enough opening. Through Sections 5 and 4 the canal is nearly choked with a heavy growth of cattails and willows. The canal banks leak and considerable adjacent land has been seeped.

On the "An-6" lateral there are several wooden drops which should be replaced. The turnout near the west line of Section 4 is nearly washed out and the culvert through the road is nearly plugged. Near the south line of Section 32 there is an inverted wood siphon 600 feet long. The pipe is in poor condition and about outlived its usefulness. Most of the pipe is lying on top of the ground without anchors or supports. It appears that timber sills may have been used at one time but have rotted out. This siphon should be rehabilitated.

On the "An-8" lateral there are several wooden structures that are about worn out or rotting. "Much of the ditch leaks and a large part of the land is seeped."

At the "An-3" lateral the "concrete intake with steel gate discharges into a wooden flume chute which is partly torn out at the lower end, and the rest of it is rapidly approaching complete collapse." There are several wooden structures along this lateral which should be repaired.

"L" MAIN CANAL

A bad condition exists at the intake of the "L" Canal. In order to fill the canal it is necessary to back water up against the toe of Lake Frances Dam "so that the invert of the outlet works is 12.7 feet below water surface." This keeps the lower toe of the dam saturated. The intake of the canal could be lowered and the canal relocated for a short distance which would serve to keep from backing water up to the toe of Lake Frances Dam, and also would reduce the velocity in the canal itself which causes scouring in the upper part of the canal and the deposit of silt in the lower reaches of the canal. A survey should be made to determine what could be done to affect the improvement and eliminate the contingencies. The canal has too much velocity throughout the hillside section which results in constant scouring along the outer side of curves and depositing of silt along the inner sides. In some places the scouring has cut halfway through the outer banks. Material washed out is carried on down the canal and deposited where the velocities are slower, which causes a continual maintenance in cleaning ditches and laterals. Some of the excess canal grade could be eliminated by rebuilding a portion of the intake end of the canal and by placing drops in the balance of the canal where the gradient is too steep. This improvement would greatly reduce the maintenance cost hereafter.

"The check for the "L-5" lateral is a timber structure with a concrete floor and paving on the side slopes. The floor is badly broken up and what may have been a downstream cutoff wall is half gone." The canal has eroded severely on both sides and bottom below the check. This structure should be repaired.

At Station 274 + 34 a timber check with concrete floor is in bad condition and should be repaired. At Station 340 + 55 there is a timber check in bad condition. Paving is broken up and the plank floor is bulged in the center. At Station 451 + 60 there is a 38-foot drop in the canal with paving in the approach to the gates and just below the gates is badly broken up". The concrete lining in the bottom of the chute is badly cracked and sounds hollow in several places." Large sections of the paving on the sides is held upright by 4" x 4" timber walers tied with wire to anchors back in the bank on either side." The canal below the drop has eroded until it is now about 100 feet wide for a distance of at least 100 feet downstream. This structure should be repaired.

The concrete structure at the "L-9" turnout is in poor condition and should be repaired. "Concrete paving below the check is all broken up and the sides and bottom of the canal are seriously eroded." At Station 212 + 50 the concrete floor in the check is badly broken up and both sides of the canal are scoured below the structure. This should be repaired. A wooden check in Section 1 is nearly gone and should be repaired.

On the "L-9" lateral in Section 11 is a concrete check, the end walls of which are leaning downstream. At the east line of Section 14 the "L-9" lateral drops 67 feet through a concrete chute. The concrete walls and floor of the drop are badly worn and deteriorated. The concrete is cracked in many places and the basin at the foot of the chute is badly broken up. This structure should be repaired.

There are many stretches of the "L" Canal which should be cleaned and the willows removed. In many places the grade is too steep which causes erosion. There are many small structures which should have been kept in repair through operation and maintenance.

OTHER CANALS AND LATERALS

The above-named canals and laterals were gone over very thoroughly in the field but there was insufficient time to inspect the remaining canals in detail. The conditions existing on the canals described above pertain to the remaining canals. In general the entire distribution system should be rehabilitated by cleaning the canals of silt, weeds, cattails and willows where necessary, repairing the small structures where repairs are needed and installing drops and checks to retard velocities which will prevent both scouring and the depositing of silt. If the canals are placed in good condition following out these suggestions, the resulting maintenance cost will be greatly reduced over what it has been in the past. This is a very important part in the operation of any project. The Valier Company should employ a civil engineer experienced in irrigation works to make the necessary surveys, plan the rehabilitation of old structures and design new structures where needed. Profiles should be run on some of the canals to determine the locations and the heights of drops needed to retard velocities.

BIG FLAT COULEE SIPHON

An inverted siphon was constructed in 1912 to carry water from the end of the "L" Canal across Big Flat Coulee to the beginning of the "S" Canal. The siphon has a total length of 4,884 feet and is under a maximum head of 160 feet. The elevation of the outlet is 15.2 feet lower than the intake. The first 950 feet is 84-inch-diameter reinforced concrete pipe cast in place. The rest of the pipe is 78-inch-diameter wood stave pipe which was originally redwood but now is a mixture of redwood and creosoted fir. "A considerable portion of the original wood is still being used, and it is remarkable that it is even able to still hold its shape. In 1945, 190 feet of the redwood stave pipe at the outlet and was completely replaced with creosoted fir. The new pipe was mounted on fir cradles with concrete footings." This new section of pipe at the outlet has been well installed and appears to be in excellent condition. The condition of the balance of the wood siphon and an itemized account of the miscellaneous repairs that have been made are best explained by the following memoranda prepared at various times by the operating engineer.

OFFICE MEMORANDUM DECEMBER 16, 1945

"The 78-inch-diameter redwood stave siphon 2,884 feet long was built in 1912. It was covered when built and required little repair until 1937. Then the lower rods had rusted away until they required replacement. This work was done in the spring of 1938. At the same time the top half of the north (outlet) end was replaced with creosoted fir for 290 feet and poor redwood staves were placed with fir the entire length. The siphon was not recovered.

"In 1943, 325 feet of new fir top was added and in 1945 190 feet of full circle fir pipe on cradles was built on the east slope and nine feet of new fir top. The new pipe on cradles with iron butt joints proved very satisfactory.

"After 1938, when the pipe is filled with water each spring a seam leak developed at the shoe tighteners on each side and it is necessary to take up the rods as the pressure increases. This work and any repair work is made more difficult because of rust on the rod threads. Several rust preventatives have been used but none have worked out.

"In general, the redwood staves continue to deteriorate and this was more apparent after 1944. In considering maintenance and replacement mention is made of the fact that, by past history, the lower rods since 1938 (7 years) have used up one-third of their expected life.

"The situation now is that measuring from the west (inlet end) there is 1240 feet of redwood pipe repaired with fir in 1938 to Station 32 + 40, 200 feet of fir top to Station 34 + 40. (The drain valve is at 33 + 30.) 450 feet of redwood to Station 38 + 90, 125 feet of new fir top to Station 40 + 15, 135 feet of redwood to Station 41 + 50, 190 feet of full circle fir on cradles to Station 43 + 40, 90 feet of fir top to Station 44 + 30, 160 feet of redwood to Station 45 + 90, 294 feet of fir top to the outlet at Station 48 + 84.

"A very thorough inspection of the redwood pipe shows poor staves at intervals from the inlet to Station 31 + 00, poor pipe from Station 31 + 00 to Station 32 + 40 where the new fir top begins, poor pipe from Station 34 + 40 to 38 + 90, and from 40 + 15 to 41 + 50.

"It must be kept in mind that there is deterioration of the 34-year old redwood staves and it is not possible to predict the maintenance need for any year or the safe life of the pipe. No staves were replaced in 1945 due to lack of men."

OFFICE MEMORANDUM OCTOBER 14, 1946

"The situation now is that measuring from the west (inlet) there is 1,240 feet of redwood pipe repaired with fir in 1938 to Station 32 + 40. (The drain valve is at Station 33 + 30). 345 feet of redwood to Station 37 + 85. (37 + 86 to 38 + 90 fir top placed spring of 1946.) 230 feet of fir top to Station 40 + 15, 135 feet of redwood to Station 41 + 50, 190 feet of full circle fir on cradles (spring of 1945) to Station 43 + 40, 90 feet of fir top to Station 44 + 30, 160 feet of redwood to Station 45 + 90, 290 feet of fir top to the outlet at Station 48 + 84."

OFFICE MEMORANDUM MAY 11, 1948

"1938 - All bottom rods replaced throughout; 300 feet of upper pipe replaced with creosoted fir. Poor redwood staves replaced through balance of pipe length."

OFFICE MEMORANDUM JULY 22, 1949

"From the full circle fir pipe built in 1945 on cradles at Station 21 + 50 : 23 + 40 to the outlet there is less pressure and from past history this should last for a considerable number of years. From Station 12 + 40 to 21 + 50 a new fir top (all fir is creosoted) has been placed and the life of this section depends on the condition of the bottom rods which are in the ground. These rods will be inspected at the close of the irrigation season. The first set lasted from 1912 to 1937.

"This leaves the inlet section from Station 0 + 0 to 12 + 40. New bottom rods in 1938 and fir replacement staves in redwood circle. The first 400 feet has less pressure and can be deferred with inspection and replacement of staves. This leaves the section from Station 4 to 12 + 40 of immediate concern with the greatest pressure and leakage from Station 8 to 12 + 40."

The wood pipe section of this siphon, with the exception of the last 190 feet which has been replaced recently, is getting old and has outlived its usefulness. The company has been able to keep it in operating condition by constant repairs. In some sections where the steel bands are under dirt cover it will be only a short time until they will need to be replaced. The remaining old redwood staves may give away at any time. If the siphon should break during the operating season, it would not only cause considerable damage along Big Flat Coulee, but would deprive the farmers of irrigation water on the bench east of the coulee. This could be quite a catastrophe if the failure should happen during the height of the irrigation season on a dry year. The old wooden section of the siphon should be entirely rebuilt. Before undertaking the work a thorough study should be made of the various kinds of materials that could be used such as steel, concrete, wood stave, etc.

WATER RIGHTS

The Valier Company owns numerous water rights, mostly from Birch and Dupuyer Creeks, which have been acquired for use on the Valier Project. Up to the present time there never has been any trouble between the company and other water right users along these streams. The company has been very considerate of other users and inclined to satisfy them in every way possible to prevent controversies over these rights. While this policy has been very amicable during the past and would probably continue the same as long as the Valier Company owned the project, conditions might be entirely different if and when the project changes hands due to the fact that there never has been an adjudication of rights under this project.

APPENDIX I

BRIEF SUMMARY OF CHANGES MADE IN THE CONSTRUCTION CONTRACT

"A list and a brief summary of the various agreements entered into between the State and the construction companies follows:

"1. Contract dated July 23, 1909, between the State of Montana, party of the first part, and Conrad Land and Water Company, party of the second part, for the reclamation and settlement of Carey Act Lands contained in Segregation List No. 8. It called for a reservoir (Lake Frances) with a capacity of 170,000 acre feet, supply canals from Birch and Dupuyer Creeks and three main canals totaling 47 miles in length. It designated that reclamation was to be completed in three years from date of contract and settlement to be completed in seven years, provided 85 per cent of lands are settled in four years.

"2. Contract dated February 21, 1911, between the State of Montana, party of the first part, and Conrad Land & Water Company, party of the second part, and James T. Stanford and W. C. Winton as receivers for Conrad Land and Water Company as parties of the third part. It amended contract No. 1 by reducing the capacity of Lake Frances Reservoir to 112,000 acre feet, and called for an additional reservoir on Birch Creek (Swift Dam) with a capacity of 30,000 acre feet. The reservoir storage to be supplemented by the direct flow of Birch and Dupuyer Creeks and Dry Fork of the Marias River, estimated to be at least 17,000 acre feet each year. It also extended the time for completion of reclamation to three years from January 11, 1911, and of settlement to seven years from January 1, 1911, provided 85 per cent of land settled within four years. (See also Fourteenth provision amending Title XIV.)

"3. Contract dated September 24, 1912, between the State of Montana and Valier-Montana Land & Water Company provided for extension and enlargement of the irrigation system to reclaim and settle Carey Lands embraced in Segregation Lists No. 12 and No. 14. It set forth the capacities in second feet of the three main canals and details for rights-of-way. It designated the time for completion of reclamation of the lands in Lists numbered 12 and 14 as four years from January 1, 1911, provided water is delivered to settlers buying water rights not later than June 1, 1913, and May 1 of each year thereafter. Settlement to be completed seven years from date of this contract provided 85 per cent of the land settled within four years. Water rights for lands in Lists numbered 12 and 14 to cost $50 per share.

"4. Agreement dated May 7, 1913, amending second paragraph of Title VII of contract No. 3 to provide for relinquishment of lands in Lists numbered 12 and 14 for which water supply is found insufficient. This contract was made between the State of Montana and Valier-Montana Land &

Water Company.

"5. Contract dated August 18, 1915, between the State of Montana and The Valier-Montana Land & Water Company purports to amend the 1912 contract to provide for extension of time to December 31, 1917, to complete reclamation of lands in Lists numbered 8, 12, and 14 and to December 31, 1920, to settle lands in these lists provided 85 per cent of lands is settled by December 31, 1918.

"6. Agreement dated June 29, 1918, between the State of Montana and The Valier-Montana Land & Water Company amended the 1909 contract to provide for a charge of $60 per share of water to be sold on lands on List numbered 8 and amended the 1912 contract to permit a charge of $60 per share for lands within the Lists numbered 8, 12, and 14.

"7. Agreement dated January 8, 1921, between State of Montana and The Valier-Montana Land & Water Company amended 1909 contract to permit a charge of $80 per share for water rights in List numbered 8 and the 1912 contract to permit a charge of $80 per share for lands in Lists numbered 8, 12 and 14.

"8. Agreement dated December 23, 1925, between State of Montana and The Valier-Montana Land & Water Company amended 1912 contract to provide for extension of time to complete reclamation and settlement of lands in Lists numbered 8, 12, and 14 to October 31, 1930. Performance bond of $40,000 required.

"9. Agreement dated April 24, 1948, between State of Montana and The Valier Company amended the contracts dated September 24, 1912, and August 18, 1915, to provide for an extension of time to December 31, 1951, to complete the construction of the irrigation system for the reclamation of the said Carey Act Lands embraced within said Lists numbered 8, 12, and 14 and called for a new performance bond of $100,000.

APPENDIX II

August 30, 1909

The Carey Land Act Board,

State of Montana

Gentlemen:

As to the break reported in the Conrad Land and Water Company's main dam, I beg to say as follows:

I visited the said dam and made an examination thereof on the 27th inst., nothing had been done towards the repair of the same, except to refill with earth the cavity formed by the leaking water.

This settling of the earth took place entirely below the core of the dam, so that the dam proper was not broken at all. Just below the core and immediately over the outlet pipe, is built a gate tower, i.e., a cement opening reaching from said pipe upward to the surface through which the gates in outlet pipe are operated. This opening is walled with cement on all sides, about one foot thick, and despite the fact that the footings of said walls were upon a good foundation in original ground which did not give way, the settlement of the dam itself around the opening caused a twisting or crushing force to crack the said cement in one corner thereof, a vertical distance of 12 to 15 feet, and through this crack the water was forced through the lower slope of the dam, which caused a settlement and outbreak which has been filled up as before.

It is now proposed and agreed upon between the Engineers of the Company and the State Engineer, that this shall be repaired in the following manner:

Reinforced concrete walls, one (1) foot thick, shall be placed within the present walls, the same to be anchored to the other walls securely, thus contracting the opening or shaft two (2) feet each way its entire depth. It will still be large enough to operate ladder ways and gate-moving device.

Such method of amendment will insure this shaft from a repetition of the damage here repaired.

Very respectfully yours,

(S) John W. Wade
State Engineer

APPENDIX III

LETTER HEAD
Engineering Department
A. W. Mahon, State Engineer
Helena, Montana

October 27, 1911

Hon. Carey Land Act Board,

Helena, Montana

Gentlemen:

I regret to report that the reservoir dam of Lake Francis, impounding water for the Valier project, is in a serious condition at the present time, requiring a section of it to be rebuilt entirely and the entire dam to be strengthened.

The engineers of the project, are at the present time, keeping the embankment under proper surveillance, and are draining the lake of all water in order to make the necessary repairs and improvements.

Under these circumstances, no particular danger is imminent, but it is a serious failure of construction that I deem necessary to formally report to your Board, and while it is the intention of the company to ascertain the exact cause of the failure and to make the necessary repairs, it will also be carefully watched by this office.

Respectfully submitted,

(S) A. W. Mahon

State Engineer

APPENDIX IV

New York, Feb. 21, 1912

C. F. Uebelacker, Esq.
Chief Engineer, Ford, Bacon & Davis
115 Broadway, New York City.

Dear Sir:

Pursuant to your verbal instructions, I left New York on February 10th and proceeded to Valier, Montana, where I inspected the Lake Francis dam. As to the results of this inspection, I now have to report as follows:

(1) The two shafts which have been put down on either side of the gate tower show that the tower itself has been badly cracked as the result of uneven settlement. The corewall, however, is undamaged and is disclosed as being of a reasonably good quality of concrete. Explorations beneath the corewall showed that the steel sheet piling projects into the concrete of the wall. The concrete in the bottom of the wall is of poor quality and shows evidences of having been deposited through water.

(2) The water in the south shaft stands at substantially the same level as does that in the excavation being made for the culvert extension downstream from the dam and there is evidence of a direct and open connection between these points.

(3) The upper portion of the core wall for a distance of about 9 ft. below its top and for a considerable part of its length has failed by being pushed toward the water side of the dam.

(4)The conduits show cracks substantially as indicated on the drawing already made and no noticeable further settlement of the condutis or enlargement of the cracks could be observed.

(5) Both banks of the Dry Fork immediately below the dam show no evidences of moisture and I believe that the sloughing of these banks has been caused by water from the lake passing under the dam either in or on the rock surface and then finding its way into the Dry Fork.

(6) The removal of the concrete floor at the downstream and of the conduits prior to extending them to the new toe of the dam disclosed that the piles on which it was founded were but 8 in. at the butt and therefore probably not over 20 ft. in length. Several 14 in. butt piles being driven for the new foundations penetrated to about 30 ft., where they brought up hard.

(7) The material of which the dam is constructed is not of the best. Little else but topsoil and disintegrated sandstone was used, although plenty of excellent material was readily available.

Briefly stated, the foregoing covers the main points which have been disclosed by the investigations and the new work to date. I will take them up with you verbally and discuss each in detail and at greater length at your convenience.

After thorough discussion of the entire situation with Wm. E. Swift, Engineer in Charge, and Hon. A. W. Mahon, State Engineer of Montana, who was on the ground during my examination of the work, I have the following recommendations to make. Some of these matters have already been talked over with you, while others have since suggested themselves.

(1) Remove all portions of upper part of core wall which have tipped over and build it anew, making tight bond with old work and tying old work to new with vertical iron rods. The new walls should be reinforced with steel rods as necessary and carried to the height of its present top (el. 3820) and buttressed so as to take the thrust of the downstream fill or else tied back with steel rods to dead-man in the bank. The selection of the method to be adopted should be left to the Engineer in Charge as only he will be in position to know which will be the more economical and best adapted when the time for a final decision arrives.

(2) The north and south walls of the gate tower should be caught up on a new foundation of piles to be driven or jetted to firm bearing in the bottoms of the two shafts. New concrete, heavily reinforced and connected to the concrete of the walls with old rails and a deep longitudinal shoulder, should then be placed to a height of about 15 feet above the shaft bottom, when the shaft should be carefully refilled after the timber has been removed. The refill should be of the same material as that which was taken from the shafts. On the top of the new concrete in the shafts and at about the level of the top of the upper conduit there should be placed a box of 100-mesh brass wire-cloth surrounding an 8-in. pipe which will be carried to the top of the dam. The height of the water within the embankment can then be determined at any time, and, if necessary, a well pump can be lowered into the pipe. An accompanying sketch (No. 1) shows the details of this arrangement. The exact details of all of this work must, however, be left to the judgment of the Engineer in Charge, so that he can take advantage of every condition as it arises and modify the general plan accordingly.

(3) Both gates and their frames inside the tower should be removed and the cross wall now obstructing the upper conduit within the gate well

should be cut out so as to afford a direct passage for the water. The space now occupied by the gate frame as well as all of the corners in the gate well, including the invert of the lower conduit, should be smoothed off with concrete and mortar, both for the purpose of improving the hydraulic properties of the conduits as well as for adding to the tightness of the gate tower itself. An accompanying sketch (No. 2) indicates what is intended.

(4) All cracks and seemingly porous places in the concrete of the walls of the gate tower, both inside and out for its full height, as well as all similar places wherever visible in the core wall should be carefully cut out, filled in and plastered with a 1:1 mortar.

(5) The entire space around the culverts upstream from the core wall should be impregnated with neat cement grout so far as is possible. This work should be slowly and carefully done and no repairs spared to make it effective.

(6) The entire space underneath the conduits downstream from the core wall and also that around the gate tower should be impregnated with neat cement grout so far as possible, but care should be taken to keep the grout from rising higher than the invert of the upper conduit. It may not be found practicable to prevent the grout from so rising, in which event as much grout as possible should be injected with the idea of filling all spaces wherever they may be.

(7) All cracks in the conduits should be carefully cut out and filled in and pointed with 1:1 mortar. A steel pipe of 3/8 in. plate should then be inserted into the conduit substantially as indicated on the accompanying sketch (No. 3). The space behind the pipe should be calked with pipe yarn and oakum in as thorough and workmanlike a manner as possible. The ends of the pipe should then be crimped up as indicated in order to prevent the caulking from being forced out in case of settlement or pressure.

(8) The plans of the Engineer in Charge for the downstream extension of the conduits are ample and no modification can be suggested. The space about these conduits should be refilled with quarry rock unless suitable gravel can be found.

(9) The downstream toe of the dam should be reinforced with quarry rock or suitable gravel up to Elevation 3795. This reinforcement need not now be carried to a higher elevation, provided the water level is kept below 3795 for the coming season.

(10) The paving of the upstream slope of the dam should be carefully gone over and strengthened by relaying that which has become displaced and by chinking all spaces between the stones. This paving was laid directly on the embankment and there is no fine stony material under it for protecting the earth of the bank against wash. In order to make the paving effective, it will, in all probability, become necessary to use grout in order to hold it together. In this connection the original earth slopes adjacent to their intersection with the slopes of the dam should also be riprapped, else with the heavy wash which is to be expected as the result of wave action on the lake the paving will very shortly become undermined and lose its footing.

(11) The old channel of the Dry Fork above the dam should be cleared out and enlarged so as to permit ready access for the water to the controlling gates as well as to prevent an accumulation of material in front of them. The material obtained by this operation should be spread out so as to cover those areas above the dam which were used as borrow pits during its construction.

(12) In order to carry a part of the weight of the easterly wall of the gate tower on the new foundations to be provided for the north and south walls, concrete beams should be placed within the gate tower. The details of this arrangement should be left to the judgment of the Engineer in Charge.

(13) All porous and rough concrete in the conduits should be cut out, filled in and plastered with a 1:1 mortar.

(14) The lower conduit, where it passed through the gate tower, should be arched over with concrete so as to provide a direct and continuous passage for the water.

(15) In order to reduce the seepage of water through and along the rock on the north side of the gate tower, holes should be put down on 15-ft. centers upstream from the core wall and close to it and to a depth of 10 ft. into the rock. These holes should then, after being scrubbed with steam, be grouted under pressure with neat cement grout. As the casing pipes are withdrawn from these holes, grout should be forced into the bank from their lower ends.

(16) The concrete trough which carried the inclined gate stems should be removed and the space it occupies, as well as that of the excavation made beneath it, should be refilled with the best available embankment material, thoroughly compacted. The riprap should then be carried over it and joined with that on either side.

(17) The operating mechanisms for the controlling gates at the upstream ends of the conduits should be placed on a suitable tower, to which access can be had either from a bridge or by a boat. The footing of this tower should be independent of the headworks of the conduits so that in the event of their movement by ice no great damage will result. No safe prediction as to the success of this arrangement can be made. The ice may render it impossible of proper maintenance, although it is believed that if the ice be kept chopped out for some distance about the tower legs no particular trouble will be had. In this connection it will be advisable to so arrange the gate stems that they can be disconnected close to the gate when the latter is shut and drawn up out of the reach of harm.

(18) In order to drain the ground in the vicinity of the conduits and below the core wall, a number of 3-inch or 4-inch pipes should be placed generally as shown on the accompanying sketch (No. 4). These pipes should be set after all grouting has been done and in holes drilled especially for the purpose. Their ends should be covered with 100-mesh brass wire-cloth and each pipe should be securely grouted into place. These pipes would connect, as shown, with horizontal pipes which should lead to some point where the flow, if any, from their ends can be observed.

(19) No water should be permitted against the dam until a weir has been built across the Dry Fork at some convenient point below it and to such height as the hydraulics of the situation will permit, the idea being to keep the effective head against the dam down to a minimum.

(20) In order to provide a new and independent outlet through the dam for use in case the old conduits should, for any reason, fail, I recommended, before seeing the ground, a siphon arrangement. I am now convinced that a better plan would be to drive a drift right through the dam and line it with concrete as a tunnel, placing the regulating gate at the upstream and as in the present conduits. This drift or tunnel would be located so that the invert would be on rock for practically its entire length. Its invert would be at Elevation__________, and its diameter would be__________ft. The details of the cross-section should be left to the Engineer in Charge, but the concrete should be mixed 1:2:4 and be nowhere less than 16 inches thick. If possible, all timber should be removed and the most thorough grouting possible done. The controlling gate for this new conduit is now on hand and the total cost for this plan would be materially less than for the siphon. It can also be more quickly done.

(21) In order to insure a tight joint between the core wall and the new conduit, a shaft should be sunk upstream from the core wall and of

sufficient dimension to straddle the conduit barrel by 4 ft. on each side. A solid concrete cut-off would then be built from the rock up to such height as may be considered necessary.

(22) The portal cuts in which this new conduit is built will be carefully refilled with selected material thoroughly compacted.

(23) Care must be taken to see that, as the ice in the lake goes out, the temporary dam now holding back the water does not also go out. This dam has practically no free-board and could not withstand wave action of any kind.

The above are my recommendations for putting the Lake Frances Dam into the best possible shape with the least possible expenditure. I believe, if these recommendations are followed that the structure can be used to store water to Elevation 3800 with safety and with a good probability of security up to Elevation 3810. Above 3800, however, and in spite of all possible precautions, little can be predicted; the uncertain character of the foundation and the unstable quality of the material of which a considerable part of the embankment is formed both combine to render inadvisable the placing of too much faith in the integrity of the structure. In case of failure, while there might be no loss of life, yet the loss in time, in property, in money and in prestige would many times over exceed the cost of even an entirely new structure.

My recommendations, then, are to make the repairs as outlined, to use the dam for the next two seasons, and in the meantime continually watch it in the most careful manner for any sign of weakness. At the end of that time more will be known concerning its behaviour, and it may then be possible to adopt a new point of view and make new recommendations.

In the meantime, however, the possibility of failure must not be lost sight of. No guarantee can be given that the dam will do the work it is now believed to be capable of doing after repaired. The lines of its design, the history of its construction, and the subsequent attempts at its repair all clearly indicate a lamentable lack of sound engineering procedure. So far as is humanly possible without resorting to the extreme of entire construction, the errors and defects of the past have, I believe, been remedied.

To sum up in a concrete manner, it is my judgment that the chances of failure with the water at varying elevations will be substantially as follows:

ELEVATION	Chances	ELEVATION	Chances
3795	1 in 5000	3810	1 in 100
3800	1 in 2000	3815	1 in 10
3805	1 in 500		

Very truly yours,
(S) Thaddeus Merriman

(17) The operating mechanisms for the controlling gates at the upstream ends of the conduits should be placed on a suitable tower, to which access can be had either from a bridge or by a boat. The footing of this tower should be independent of the headworks of the conduits so that in the event of their movement by ice no great damage will result. No safe prediction as to the success of this arrangement can be made. The ice may render it impossible of proper maintenance, although it is believed that if the ice be kept chopped out for some distance about the tower legg no particular trouble will be had. In this connection it will be advisable to so arrange the gate stems that they can be disconnected close to the gate when the latter is shut and drawn up out of the reach of harm.

(18) In order to drain the ground in the vicinity of the conduits and below the core wall, a number of 3-inch or 4-inch pipes should be placed generally as shown on the accompanying sketch (No. 4). These pipes should be set after all grouting has been done and in holes drilled especially for the purpose. Their ends should be covered with 100-mesh brass wire-cloth and each pipe should be securely grouted into place. These pipes would connect, as shown, with horizontal pipes which should load to some point where the flow, if any, from their ends can be observed.

(19) No water should be permitted against the dam until a weir has been built across the Dry Fork at some convenient point below it and to such height as the hydraulics of the situation will permit, the idea being to keep the effective head against the dam down to a minimum.

(20) In order to provide a new and independent outlet through the dam for use in case the old conduits should, for any reason, fail, I recommended, before seeing the ground, a siphon arrangement. I am now convinced that a better plan would be to drive a drift right through the dam and line it with concrete as a tunnel, placing the regulating gate at the upstream and as in the present conduits. This drift or tunnel would be located so that the invert would be on rock for practically its entire length. Its invert would be at Elevation____________, and its diameter would be____________ft. The details of the cross-section should be left to the Engineer in Charge, but the concrete should be mixed 1:2:4 and be nowhere less than 16 inches thick. If possible, all timber should be removed and the most thorough grouting possible done. The controlling gate for this new conduit is now on hand and the total cost for this plan would be materially less than for the siphon. It can also be more quickly done.

(21) In order to insure a tight joint between the core wall and the new conduit, a shaft should be sunk upstream from the core wall and of

sufficient dimension to straddle the conduit barrel by 4 ft. on each side. A solid concrete cut-off would then be built from the rock up to such height as may be considered necessary.

(22) The portal cuts in which this new conduit is built will be carefully refilled with selected material thoroughly compacted.

(23) Care must be taken to see that, as the ice in the lake goes out, the temporary dam now holding back the water does not also go out. This dam has practically no free-board and could not withstand wave action of any kind.

The above are my recommendations for putting the Lake Frances Dam into the best possible shape with the least possible expenditure. I believe, if these recommendations are followed that the structure can be used to store water to Elevation 3800 with safety and with a good probability of security up to Elevation 3810. Above 3800, however, and in spite of all possible precautions, little can be predicted; the uncertain character of the foundation and the unstable quality of the material of which a considerable part of the embankment is formed both combine to render inadvisable the placing of too much faith in the integrity of the structure. In case of failure, while there might be no loss of life, yet the loss in time, in property, in money and in prestige would many times over exceed the cost of even an entirely new structure.

My recommendations, then, are to make the repairs as outlined, to use the dam for the next two seasons, and in the meantime continually watch it in the most careful manner for any sign of weakness. At the end of that time more will be known concerning its behaviour, and it may then be possible to adopt a new point of view and make new recommendations.

In the meantime, however, the possibility of failure must not be lost sight of. No guarantee can be given that the dam will do the work it is now believed to be capable of doing after repaired. The lines of its design, the history of its construction, and the subsequent attempts at its repair all clearly indicate a lamentable lack of sound engineering procedure. So far as is humanly possible without resorting to the extreme of entire construction, the errors and defects of the past have, I believe, been remedied.

To sum up in a concrete manner, it is my judgment that the chances of failure with the water at varying elevations will be substantially as follows:

ELEVATION	Chances	ELEVATION	Chances
3795	1 in 5000	3810	1 in 100
3800	1 in 2000	3815	1 in 10
3805	1 in 500		

Very truly yours,
(S) Thaddeus Merriman

Appendix No. 17

OFFICE OF THE STATE ENGINEER, HELENA MONTANA

Valier

REPORT ON CONTRACT BETWEEN THE CAREY LAND ACT BOARD OF THE STATE OF MONTANA AND THE VALIER MONTANA LAND AND WATER COMPANY

By J. S. James State Engineer and
Secretary of the Carey Land Act Board

Office Copy

April 15, 1930

The Carey Land Act Board,

Hon. J. E. Erickson, Governor,

Hon. L. A. Foot, Attorney General,

Hon. W. E. Harmon, Secretary of State.

Gentlemen:-

I beg to submit the following Report on Contract between The Carey Land Act Board of the State of Montana and The Valier Montana Land and Water Company covering reclamation of lands in the Valier Carey Act Irrigation Project:

Respectfully

J. S. James
State Engineer
Secty Carey Land Act Board

Valier Project
Description

The Valier Project is located in Pondera County, Montana comprising approximately a total of 80,000 acres irrigable land, about 50,000 acres of which is Carey Land 30,000 acres other lands.

Water Supply is from Birch Creek and Dupuyer Creek stored in two reservoirs of combined capacity of 142,000 acre-feet. The elevation of the land varies from under 3500 feet to over 3800. Soil is quite uniformily adapted to irrigation and the growing of all crops suited to this climate. Seepage affects only relatively small areas. Water right or irrigable feature of lands is evidenced by stock in Pondera County Canal and Reservoir Company, each share of such stock representing irrigation right for one acre.

This development was started as a Carey Act project with the segregation of "List 8" and contracting for construction by the Conrad Land and Water Company in 1908 and 1909. Later "Lists 12 and 14" were segregated, these three lists comprising the present total of approximately 50,000 acres of Carey land. The rights of the Conrad Land and Water Company, have, by sale and reorganization at various times, passed to the ownership of The Valier Montana Land and Water Company and the original contract, by amendment and substitution has become the present contract between the Carey Land Act Board and The Valier Montana Land and Water Company.

On June 1st, 1929, a letter from the Vice President of the Valier Company was received by the Carey Land Act Board, stating that it was the opinion of the writer that the irrigation system was complete according to the contract between the State and the Company, and requesting the Board to make an examination of the project to determine whether the system is so completed. The Carey Land Act Board thereupon directed the State Engineer to make such examination and report his findings to the Board as soon as possible.

The examination so directed has been made and the findings and recommendations are respectfully submitted in the present report.

As above noted, the project does not consist exclusively of Carey land. However, the irrigation right being represented by the same stock in the Pondera County Canal and Reservoir Company for all lands, it is considered that the same provisions must apply to all lands as the project must be considered as a whole. Therefore, all canals and structures are considered as under the contract alike, whether serving Carey lands or other lands to which is applied stock in the Pondera County Canal and Reservoir Company.

Various provisions of the contract will be considered as follows:-

- (1) General purposes of the Contract. (Title 1)
- (2) Specifications for Construction. (Title 11)
  - (a) Lake Francis Reservoir.
  - (b) Swift Dam,-Known as Birch Creek Reservoir.
  - (c) Retaining Dam,-Known as Lake Francis Dam.
  - (d) Other Structures.
  - (e) Intake Canal. ("B", "D", & "C3" Canals)
  - (f) Main Canals.
  - (g) Laterals.
  - (h) Canal Capacity.
- (3) Right of Way. (Title 111)
- (4) Time Limit. (Title IV)
- (5) (a) Water Supply. (Title VII)
  - (b) Point of Delivery.
- (6) Transfer and Management of System. (Title VIII)
  - (a) Authorized Capital Stock.
  - (b) Non Assessable until Appurtenant to Land.
  - (c) Evidence of Each Share.
  - (d) Transfer of rights.
- (7) Measurement of Water. (Title X)
  - (a) Point of Measurement.
  - (b) Rotation.
- (8) Apportionment of Water. (Title XI)
- (9) Maintenance. (Title XII)
- (10) Completion of System. (Title XIV)
- (11) Bonds. (Title XX)

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(1) General Purposes of Contract. (Title I)

The general purpose of this contract is here interpreted to mean the insurance of the construction of a good workable irrigation system with an adequate water supply for the lands involved. In this contract, this general purpose is limited by few detailed specifications, but provision is made for details to be specified from time to time by the State Engineer for the Carey Land Act Board. Results specifically required may be summed up in the requirements for a system of diversion, impounding and distribution works to serve all land simultaneously at the rate of one sec. ft. (cubic foot per second) for each 100 acres of water right land, and the furnishing of a water supply sufficient to deliver one and one-half (1½) acre feet of water to each water right acre each and every year.

[illegible]

Specification in the contract, or those made from time to time by the State Engineer are merely for the insurance of these results and for the insurance of a class of construction likely to be free from excessive future maintenance costs.

In the present investigation and report, it is the purpose to determine whether the system fairly fulfils the above requirements, rather than a too close adherence to certain details of specifications

(2) Specifications for Construction. (Title II)

(a) Lake Francis Reservoir is required to be built to a capacity of approximately 112,000 acre feet. This requirement has been met, - except as noted under "c" below.

(b) Swift Dam, - Birch Creek Reservoir, is required to be built to a capacity of 30,000 acre feet. This has been complied with.

(c) "Retaining Dam", - known as Lake Francis Dam, -is specified to be an earth fill dam fiftysix feet in height, with steel piling and concrete, core wall, top width 20 feet, upstream slope 1½ horizontal to 1 vertical, -riprapped-, downstream slope 3 to 1. Fitted with two 54 inch reinforced concrete outlets with four 54 inch Coffin "sluice gates".

The specification for height must be interpreted by the requirement for a storage capacity of 112,000 acre feet. This requirement has been met in part. The top of the dam is at elevation 3821.0 and the elevation of water surface to give 111,900 acre feet storage, is 3816.0, giving a freeboard of 5.0 feet. This is much less than is usually allowed for this type of dam, but the water was held at approximately elevation 3816.0 for a considerable time in 1928, with no alarming increase of seepage. It is therefore recommended that the present height of the body of the dam be approved as sufficient. However, the freeboard of five feet does not provide protection from wave action and splash, and for this protection it is recommended that there be required a coping wall of permanent construction or other satisfactory wave protection raised to at least elevation 3824. This requirement should be absolute, admitting of no compromise, as it is necessary to insure the safety of this structure the failure of which would ruin the project and causeincalculable damage to other property and danger to life.

The top width of the dam is approximately twenty feet as required, and is considered sufficient.

The upstream face has an average slope flatter than the 1½:1 specified, the lower part being 3:1 but the upper part has washed down by wave action and stands at somewhat steeper slope. On this steep slope the riprap of field stone does not hold up to the top of the core wall. It is recommended that there be required some addition to this upstream slope, either with an excess amount of field stone, to allow for future sliding or with some material not subject to this sliding. In some manner it should be brought to a permanent slope not steeper than 1½:1 from the top of the core wall.

The outer or downstream slope is rather better than contract requirement, being reinforced with a berm up to about 2/3 the height of the dam. This item is satisfactory.

The dam is provided with two 54 inch reinforced concrete outlets as specified, but with only two gates, that is, only a single control in each outlet pipe, while the specifications call for four gates, implying a double control of each pipe. Provision for double control is important in this location, where failure of a gate may cause considerable loss of service and loss of valuable stored water. The present gates are operating satisfactorily, altho one shows a crack in the wedge or disc. One of these gates cannot be repaired or replaced, nor can double control be installed economically, without draining the reservoir. This would endanger the project water supply for the following year, so it cannot be recommended that these changes be made until such time as a low water year empties the reservoir in the course of operation. It is recommended, however, that double control be installed on these outlet pipes at the first opportunity and that, should the project be turned over to the Pondera County Canal and Reservoir Company before such time, The Valier Montana Land and Water Company set over to the Pondera Company the amount of the estimated cost of such improvement.

There are some leaks in the outlet pipes, which, tho they do not necessarily indicate a dangerous condition, should be investigated and properly repaired from the outside when the reservoir is empty. Provision should be made for this item as for the gates, in case the project is turned over to the settler's company.

The general condition of Lake Francis Dam may be approved, -subject to the above suggested betterments, - due to apparently satisfactory operation under full load in 1928. There is leakage or seepage thru or under the dam, but this did not materially increase with raising the water to high level, and this leakage seems to be decreasing, in general, with the passing of time. The history of the early construction of the dam is obscure, leaving uncertainties as to original conditions, foundation etc., and neither the material or design would be approved for a new structure. However, it was carefully repaired, the core wall and foundation grouted and the outlet pipes repaired in 1911, under direction of engineers of high standing. Since that time it has operated successfully, so, except for the items above mentioned, it is recommended that it be approved.

(d) Other Structures.

Among these, the most important is "Swift Dam". This is a rock fill dam with reinforced concrete face. Some repairs to the face have been necessary and the control gates are not entirely satisfactory, requiring considerable maintenance, but fifteen years of operation have shown this structure to be, in general, satisfactory. Measurements show that settlement is not excessive and that the rate of settlement is decreasing. It is recommended that this structure be approved.

The 78 inch wooden pipe line mentioned in the contract, -now known as "the syphon", - was carefully inspected. This is a well built structure of the type specified in the contract. It is not a "permanent" structure but is one that can, with careful inspection and maintenance, be kept in service indefinitely. Some staves have failed thru crushing due to improper operation and some have decayed, but there is little evidence of general decay. As staves have failed, they have been replaced in the course of maintenance, and the future replacement of staves is a proper matter of maintenance. Few, if any, bands have failed as yet, but in time these will rust out. If bands are replaced as soon as they show weakness and failing staves are promptly replaced, thereis no reason to expect a general failure and replacement of this structure at any future time. It is recommended that this structure be approved.

The contract specifies that all turnouts from main canals shall be of concrete. This was later amplified by an order of the State Engineer, requiring all structures to be of concrete, in canals of over fifty second feet capacity. This rule has, in general, been complied with. Some exceptions were made and specific approval given for certain part timber structures. The only notable failure to meet this rule is in certain structures in the main supply canal. These will be noted under sub-head (e) below.

"The Flume" is a semi-circular steel flume on a high timber trestle, on the "P" or Pondera canal. This flume was of poor design originally, but has been rebuilt to good servicable condition. Little deterioration is noted in the metal. The timber sub-structure has showed some failure of individual members which have been replaced in course of maintenance. With proper inspection, such replacement can be carried on indefinitely without risk of failure. Some slipping has occured of the hillside under the footings of the bents near the down-stream end. Provision has been made for adjusting these footings to compensate for this movement. The rate of this slipping has greatly decreased so there seems little danger of a sudden movement which would cause failure of the structure.

The present capacity of this flume was determined by measurement at approximately 130 second feet. As this is the amount required to be delivered to the land below, this structure is rated as 10% under required capacity. The required additional capacity can, perhaps, be obtained by readjustment in the gradient of the flume, tho new steel of larger effective diameter may be required at the upstream end. It is recommended that the indicated additional capacity be required and with this exception, the structure be approved.

The wasteway diversion above the "P" flume discharges thru a timber chute down the hillside. This chute is in bad repair and should be replaced with a structure of concrete or sheet metal or other more permanent form of construction.

The ditch from the wasteway at the end of the "L" canal above the "syphon" requires a structure to prevent scour.

Concrete structures in general over the project have been maintained in good working condition. There have been some partial failures, which have been repaired and the original weakness of the structures corrected. Minor repairs were noted as needed on several structures, but these may be considered as matters of maintenance, with, perhaps, the exception of the outlet of the "S" drop, the repair of which should be considered as an item of completion.

Timber structures have been generally maintained in good condition. Most of the original timber turnouts have been replaced with practically permanent structures of tile. Other timber structures, such as checks and drops, are maintained in servicable condition and can be so maintained and gradually replaced in the future without excessive maintenance charge.

(e) Intake Canal. (B, D & C3 Canals)

The intake or supply canal, is, in the nomenclature of the project, divided into three parts, the "B" canal, from Birch to Dupuyer Creek, the "D" canal from Dupuyer Creek to the diversion of the "C" canal, (the first large distributing canal), and the "C3" canal from this point to the reservoir. The contract requires that the "B" shall have a capacity of 700 second feet and the "D" and "C3" canals capacity of 900 second feet. Under test in 1929, the "B" canal satisfactorily carried the required capacity of 700 second feet.

It was not possible to test the "D" and "C3" above 700 second feet, but these canals have carried upward of 1000 second feet for short periods and by observation of their operation under a load of 700 second feet, it is believed they will satisfactorily carry the 900 required, except for a portion of the "C3" where the channel is meandering. This condition will not affect the operation of the canal but may cause considerable damage to the adjoining land. Should sufficient right of way be provided to allow for possible future meandering of this channel, this canal would be acceptable.

Along the line of the "B" canal are some twenty-four timber drops. These structures are operating satisfactorily but do not comply with the ruling of the State Engineer requiring concrete, (permanent), structures in main canals. However, it would be poor economics and poor engineering to replace these structures while they are operating satisfactorily. This "B" canal is an elargement of an old canal, located and designed for different conditions. Its development to the required capacity has been largely a matter of experiment, -"cut and try"-, both as to channel and as to structures. Conditions developing under increasing loads have indicated necessary protection work and additional drops, or different form for certain drops. These indicated changes and betterments have been made to the point where the canal safely carried 700 second feet for four to five days. Results of this test run indicated some additional protection work and some enlargement of pools below drops. Intelligent maintenance will constantly improve this canal and its structures, so that it may fairly be considered as meeting the contract capacity requirement.

However, the temporary character of the structures indicate a somewhat higher future maintenance cost than would be expected with the more permanent type of structures specified by the State Engineer. It is recommended that this canal be approved on condition that there be some offset to allow for repair and replacement of these temporary structures.

(f) Main Canals.

The Contract specifies the capacities of three main distribution canals. These are now known as the "C", the "An" and the "L" canals. The required capacities now are reasonably those that meet the general project requirement of simultaneous delivery of one second foot for each 100 acres. Reduction in acreage has reduced this requirement since the canals were built, so that they are all considerably over the project requirement in capacity. In 1929, the "C" canal carried nearly 100% over contract capacity basedon acreage. These canals are approved.

(g) Laterals.

Under this heading are included all other canals and ditches than those in (e) and (f) above. These are all constructed and in satisfactory operation. It is believed that all capacities meet the contract requirement with the possible exception of some temporary condition requiring maintenance. In general, full delivery of water as ordered was made in 1929, altho the delivery loaded practically all canals and laterals from 10% to 100% over contract requirement. The one exception to this is the "Pondera" system where the limited capacity of the flume, (noted under structures), held delivery below contract requirement, altho it still met, I believe, all demands actually made.

(h) Canal Capacity.

This is covered above.

In General, regarding condition of the whole system, canals and structures, it should be noted:

There is more or less deterioration of structures, and in some ways, of canals. We think, ordinarily of a completed contract as turning over new structures, unimpaired by use and time. However, this contract provides for the transfer of the project at some time during the course of operation. This implies some indefinite amount of deterioration as being anticipated. We may also compare the system as it is, with what it would have been had it been completed at once, -say in 1915- strictly according to specifications, ready for service as far as could then be forseen. Taken over in that condition, service would have shown many defects of design and location, -which only service could have shown, - requiring repairs, revisions and reconstruction. This would have been expected. As the system now stands, these corrections have been made. Many structures have been rebuilt to meet actual conditions which were not and could not be forseen. Additional bank protection and controls such as drops and checks, have been installed where shown to be necessary. These corrections, revisions and additions found necessary to meet actual conditions of service, may be considered to fairly offset deterioration during the time the project has been held incomplete by the contracting company.

(3) Right of Way.

Rights of way for canals, laterals and service ditches over Carey land and, in general, over all water right land is provided in the contract. Rights of way over other private lands have generally, if not in every case, been obtained by the contracting company. Where, if anywhere, these rights have not been purchased, right has probably been perfected by use. However, in the case of State land no adverse right thru use could be obtained. It is, therefore, undoubtedly part of the contract for the Company to show rights of way over State lands. It appears that such rights have not all been obtained and it is recommended that any not so obtained be required.

(4) Time Limit.

The date for completion has been extended from time to time by supplemental agreement. The present time limit being October 31st, 1930.

(5) Water Supply, (Title VII)

(a) Detailed analysis of water supply is appended to this report. Some uncertainties exist as to data on which this analysis is based. Losses from canal seepage and evaporation and from regulation have not been closely determined by operation. The total of these losses was assumed at 15%, which is less than most authorities would allow. As water rights have not been adjudicated, the amount of prior right demand is unknown. This was assumed at what was believed to be a low, rather than a high, figure. It was intended to give the contracting company the "benefit of doubt" in all cases of uncertainty.

The contract stipulates a water supply sufficient to furnish each acre with one and one-half acre feet of water, (18 inches in depth), "each and every year". This modified in Title XI of the contract which states that "the party of the second part" (The Valier Montana Land and Water Co.) "does not undertake to guarantee the quantity of water which may be supplied hereunder during any irrigation season". This is a proper provision, as any well balanced irrigation project with an adequate supply, may, under extreme conditions, suffer some shortage in a single year. However, it is undoubtedly the intent of the contract that the Company provide a water supply reasonably adequate for the irrigation of all lands to which water stock is applied. It was necessary to define or measure the amount of such adequate supply which the Company contracted to furnish. This was done in the above phrase, "one and one-half ($1\frac{1}{2}$) acre feet each and every season" for each acre of water right land, which means for each share of applied stock in the Pondera County Canal and Reservoir Company.

Now it becomes necessary to interpret this requirement in terms of the practical requirements and actual demands of this land. Under the condtions of annual precipitation varying from little over six inches, to nearly twenty inches, the land does not require or demand one and one-half acre feet or any other fixed amount, "each and every year". The actual demand for the full production of crops would vary from about six inches to about 30 inches. So this requirement of the contract needs interpretation. It may be considered as meaning a supply reasonably expected to furnish (1) $1\frac{1}{2}$ acre feet, (18 in.) any year demanded, or (2) an average demand of 18 inches per year. Without assuming any definite interpretation, but keeping in mind that there may be different interpretations, it was decided to show what service the available supply could have given during the past 21 years,- for which records of stream flow and precipitation are practically complete,- as an indication of what service can reasonably be expectedin the future.

It was first determined that the available supply would have furnished an average net to the land for a project of 80,000 acres of about 15 inches per year and that this amount with the average precipitation of 12.5 inches would give an average effective moisture of 20 inches, assuming two inches of irrigation water equal to one inch of precipitation. This 20 inches effective moisture is taken as the "ideal" amount for each season, -not that it is the truly ideal amount for the production of crops, which might be somewhat higher,-but as the amount which the known supply might reasonably be expected to furnish. Assuming certain proportions of the total 20 inches for each month of the irrigation season, "Table 1" was prepared showing the net amount of irrigation water that would have been required each month for the 21 years of record.

"Table 2" shows the gross requirement each month in acre feet determined by adding to the net amounts of Table 1, 15% for losses, and modifying further by assuming that not more than 50,000 acre feet would be demanded in any one month and that not less than 3,500 acre feet would be used in any one month. "Table 3" shows the operation of the project under project demand as above determined, prior right demand assumed as about 15% project demand, with 5,000 acre feet maximum monthly demand and 530 minimum, with 500 acre feet per month outside irrigation season for livestock requirements etc. in Birch Creek. Evaporation losses from the reservoirs were figured on the surface area each month, based on pan evaporation records. The calculation of Table 3, was necessary to determine reservoir losses and losses from lack of capacity. The results of Table 3 are shown by years on Table 4 (a).

Table 4 (a) shows serious shortage in only two years, 1919 and 1921. Table 4 (b) shows operation under assumed demand of 18 inches (Contract) each and every year. This shows serious shortage in the same two years and below contract in 13 out of 21 years. As table 4 (a) is based on an average use of only 15 inches, either view point seems to show that the water supply is somewhat below any reasonable interpretation of the contract. To get some measure of the margin below contract we may take Table 4 (a) as showing a satisfactory use of fifteen inch supply, and say the supply was short of contract 3/18 or 1/6, which would reduce the allowable acreage from 80,000 to 67,000, or we may take Table 4 (b) which gives an average gross available of 118,860 acre feet annually, which, -allowing 15% for losses, would give 18 inches net averageon 68,900 acres.

Mr. C. E. Atwood, Chief Engineer of the Valier Co., contends that 15,000 a. f. is sufficient for the extreme demdands of prior rights, instead of 20,000 a.f. This contention is supported bya supplemental contract between the Valier Co. and the Indian Service, -not before called to my attention, -reducing the acreage of Indian lands to be supplied from 7,000 to 5,100, and by the records of the past years which shows the actual demand of prior rights to have been about 10,000 a.f. for the irrigation season. To this 10,000 would be added 3,000 for stream flow outside the irrigation season, making a total of 13,000 a.f. Using 15,000 for the prior right demand would leave a balance of 2,000 a.f. to allow for future increased Indian use. This contention seems reasonable and may be conceded, thus adding 5,000 a.f. to the available supply as determined above. On the other hand, the operating record of the Company shows the actual loss from Lake Frances to average about 1,500 a.f. more than used in the present calculation. Taking both these corrections, gives a net addition of 3,500 a.f. or 2,100 acres to be added to the above figures, making the theoretical project acreage, 69,100 from table 4, (a) and 71,000 from table 4 (b).

Other analyses of this water supply both by Atwood and by Government Carey Land Inspectors have considered a percentage of unused land as deductable from the irrigable acreage. This is not here considered, as all permanently nonirrigable land should be and doubtless will be taken from irrigation charge. Each share of stock represents irrigation right for one acre and this stock cannot in reason be applied to land in building sites or public roads or to seepage or "high" land on which irrigation water cannot be used. While this stock is said to be "inseparably appurtenant" to certain land, it has properly been separated from certain non-irrigable areas and should in the future be separated from all such areas as they develop. In spite of wording of by-laws or statutes, it is unbelievable that a Court would hold that an irrigation right must be tied as a burden to land that cannot use it, and thus forever withheld from other land in need of irrigation. Thereforeit is considered that the full amount of the stock of the Pondera County Canal and Reservoir Company represents the acreage eventually demandingservice.

It is believed the present calculation fairly shows the service that the present system can be expected to give to 80,000 acres. This shows an economical use of the available supply, possibly a more economic duty of water, but still a higher one than contemplated in the contract.

From these figures, it would appear that a rigid interpretation of the contract might limit the total irrigable acreage of this project, -as far as this contract is concerned, -to somewhat below 80,000. That is, the total outstanding stock of the Pondera County Canal and Reservoir Company, at the time of acceptance by the State, should not exceed such amount. However, such a rigid interpretation may not be justified. The United States has allowed patent to Carey land on a basis of approximately 80,000 total acreage, (allowing 10% for non-use) and the contracting company has proceeded in good faith with the development of the project on this basis. The actual requirement of this land for irrigation water is, in myopinion fairly determined by consideration of actual rainfall as shown on Tables 1 and 2. Tables 3 and 4(a) show the working of such requirement during the 21 years of record. These show, as above stated, only two years seriously below assumed demand. Two short years in 21 seems a reasonable allowance. An economical development of any water supply cannot be made without the expectation of some shortage under extreme conditions of rare occurence. To provide against such shortage would require either cutting acreage to so low a point that there would be excessive waste of water on the average year, or the providing of excess storage for long carry-over which could not be economically justified. The analysis shows an unusually complete conservation of the available supply, and a fair economic use of the water conserved.

-Adjudication of the water rights from Birch and Dupuyer Creeks would somewhat clarify the water supply question, -in fact, such adjudication is necessary to an exact statement or analysis of this supply. It may be that adjudication of these rights should be required for completion of this project, but this is a legal, rather than an engineering, question.

The general question of the adequacy of the water supply or the amount of land, or stock, to be allowed, is submitted with the recommendation that the supply be approved for not to exceed 80,000 acres, -or total of all shares of stock applied and unapplied at the time of transfer of the project to the Pondera County Canal and Reservoir Company.

(b) Point of Delivery.

The contract provides that, for Carey Land, water shall be delivered not more than one half mile from each legal subdivision. It is believed that this requirement has been met.

(6) Transfer and Management of System. (Title VIII)

(a) Authorized Capital Stock.

To provide for management and ultimate ownership of the project, the contracting company formed the Teton County Canal and Reservoir Company, which has been changed to the Pondera County Canal and Reservoir Company. This company was formed "with an authorized capital stock of ---(160,000) shares, which amount is intended to represent one share for each acre of land to be irrigated from said system". In view of the determination of water supply it would seem that the amount of capital stock should be limited to the number of acres that can reasonably be served from the supply, or at least the number of shares issued prior to transferring the project should be so limited, which is recommended not to exceed 80,000 shares.

(b) It is provided that stock shall be non-assessable and non-voting until applied to and made appurtenant to land.

(c) The contract provides that each share of stock in the Pondera County Canal and Reservoir Company, "shall", -when the title to the system has been transferred, -"represent a proportionate interest in said system, ---based upon the number of shares finally sold in said system". This implies the limitation of sale of stock to the size project finally determined by water supply or other conditions.

(d) Transfer of Right.

Contract provides that when 90% of water rights have been sold and paid for, the constructing company shall and at any time prior to such sale, with the consent of the Carey Land Act Board, may transfer by proper conveyance to the Pondera County Canal and Reservoir Co. "all its right, title and interest (except the right to sell -- any unsold water rights therein) in and to said irrigation system----". As the water supply is calculated upon the full flow of Birch and Dupuyer Creeks and normal flow of Dry Fork, all water rights of The Valier Montana Land and Water Company in those creeks should be included in this transfer whether specifically mentioned in the contract or not. ?

(7) Measurement of Water. (Title X)

Contract provides that the contracting company will install headgates and measuring devices in canals, reservoirs and main laterals and that water users are to build and furnish measuring devices for their own use. By rated canal sections, gates flumes and weirs the company has fairly well met their part of this provision. They have also made approximate rating of individual turnout gates, providing some degree of measurement to the water user.

This title repeats the provision for the delivery of water for Carey land at a point not over one half mile from each legal subdivision and for a total carrying capacity "sufficient for the simultaneous delivery" of one second foot of water for every one hundred acres of land. As stated above, it is believed these provisions have been met.

(8) Apportionment of water. (Title XI)

As quoted under "Water Supply" the company does not guarantee the quantity of water to be supplied any one year and the contract provides that "if, for any reason, there should be a shortage of water during any irrigation season, said shortage not being due to any neglect or default of the party of the second part" (The Valier Montana Land and Water Company) "then the amount of water furnished to any pruchaser or owner of water rights in said system shall represent"a proportionate amount of the available supply. This is plainly true. When the project is owned by the settler's company all stockholders must share alike, in proportion to their holdings, in whatever water right or supply there may be and for this reason the integrity of the Carey Act reclamation and the title to the Carey Act lands depends on the reasonable assurance of the anticipation of a fairly adequate average supply. The measure of such supply is repeatedly stated in the contract as being one and one-half acre feet per acre each and every year. The Carey lands have no prior or superior right to the water supply and the only way the right to those lands can be assured is to limit the total acreage of the project to what can reasonably be supplied from the water available.

Title XVII provides that water may be furnished to cities and towns. That is, municipalities may hold stock in the Pondera County Canal and Reservoir Company for municipal water supply.

(10) Bonds.

Bond in the sum of $100,000 is conditioned upon the supply of water to Carey lands in lists 8, 12, and 14 and provides for repayment to settlers for payments and improvements on any lands for which water is not furnished. This bond was filed November 27, 1915, The Valier Montana Land and Water Company as Principal and C. D. Conrad of Kalispel and Geo. H. Stanton as Sureties.

Bond in the sum of $50,000 is "conditioned for the faithful performance of all the said contracts herein referred to". This bond was filed December 7,1915, The Valier Montana Land andWater Company Principal, and Robert Russell "of Valier" and J. A. McDonough of Great Falls, Sureties.

Summary and Conclusions.

It is concluded that, in the opinion of the writer, the fore-going presents conditions pertinent to the acceptance of the Valier Irrigation Project, recommendations being summarized as follows:

(1) The contract has been carried out in good faith and in general there is a virtual compliance with its provisions, except as noted.

(a) Lake Francis storage reservoir is built to required capacity.

(b) "Swift Dam", Birch Creek Reservoir, is built to required capacity.

(c) Lake Francis Dam requires, (1) coping or other additional height to give eight feet freeboard above high water: (2) addition to upstream slope: (3) Double control on both outlet pipes: (4) Repair of leaks in outlet pipes.

(d) Other Structures:

(1) Swift Dam be approved.

(2) 78 inch wood pipe (Syphon) be approved.

(3) Other structures in general be approved.

(4) "P" canal flume be rebuilt to provide 10% greater capacity.

(5) Chute from wasteway above "P" flume be rebuilt in more permanent form.

(6) Drop Structure be placed in "L" canal spillway outlet above Syphon.

(7) Outlet of "S" drop be rebuilt.
(8) Timber structures in general be approved.
(9) Minor repairs and replacements on structures in general be considered as proper matters of maintenance.

(e) Intake Canal, the "B", "D" and "C3" canals, be approved as to capacity. That additional right of way be furnished for the"C3" canal. That provision be made for eventual replacement of temporary structures in these canals.

(f) Main Canals, "C", "An" and "L" canals be approved as to capacity.

(g) All other canals and laterals be approved as to capacity, -except limited capacity of "P" flume, (Noted under "D").

(h) General condition of canals and structures be approved, considering betterments offsetting deterioration.

(3) Rights of Way be obtained over State land.

(4) Water Supply be approved for not to exceed 80,000 acres, in the judgement of the Board. Question of adjudication of water rights submitted to the Board for its consideration.

(5) Point of delivery of water for Carey land be approved.

(6) Transfer and Management of System. Authorized stock in the Pondera County Canal and Reservoir Company should not, at the time of transfer, exceed acreage for which water supply is found adequate.

(7) Provisions for measurement of water be approved.

(8) Provision for apportionment of short supply of water, emphasizes need for limitation of water right stock.

Respectfully submitted,

State Engineer,
Secretary, Carey Land Act Board.

SUMMARY and CONCLUSIONS
Comments on Report by C. E. Atwood, Chief Engineer
Valier Montana Land and Water Company.

On Matters Which Now Have Been Discussed by the State Engineer and the Undersigned Pertaining to the Acceptance by the Carey Land Act Board Construction on the Valier Project.

LAKE FRANCIS DAM.

Plans for thisstructure have been approved by the State Engineer and have been, therefore, considered as acceptable to the Carey Board. As to how much weight the approval thus given to a plan carries with the Carey Board is a matter which must be determined legally. However, if it is true that such approval can be over-ruled by the Carey Board after the structures are installed and have been successfully operated for a number of years then the entire structural system which has been considered as meeting the approval of the Board through its duly authorized agent as to structural features can certainly be considered in a light which would not only be unfair to the construction company, but would jeopardize its entire investment. I believe it was the original intent of those who made and entered into the contract in behalf of the State and the construction company to have placed in this document the requirement that the State Engineer approve all plans in order that the construction company would know when an installation was made it would meet with the approval of the State of Montana and thus save the expense to the construction company of removing structures and reconstructing them to satisfy the ideas of constantly changing officials.

"P" SYSTEM:

In this system you are going to recommend that the capacity of the "P" flume be increased and the waste way from the intake of the structure be reconstructed in a permanent manner. It is not the intention of the Water Company to jeopardize the delivery of the water in this system in any way whatsoever nor has it been its intention to try saving on the construction features to the extent that the settlers in this district could not receive a square deal. However, it is always been considered by the Water Company and so regarded by past State Engineers that the "P" canal system did not come under the contract with the State of Montana. This system has been built with adequate capacity, with the possible exception of a slight shortage in the "P" flume, to amply and economically serve the lands involved. Hence, the existing system has been considered by the construction company as complying with its agreement with the old Pondera Canal Company and the policy used with reference to this system in the past has been followed under this impression.

DROP STRUCTURE INTAKE
BIG FLAT COULEE SYPHON

It is agreed this structure must be installed.

OUTLET "S" DROP

It is agreed this outlet must be rebuilt.

RIGHT-OF-WAY 3-C CANAL

The Construction Company now owns the land through which this canal passes, consequently the land if sold will carry a blanket right of way reservation.

"B" CANAL

Plans for timber drops in these canals have been approved by the State Engineer. As to my opinion on the status of these structures refer to remarks under Lake Francis Dam. Although these structures are in part built of timber, I believe that their past history conforms to the original intent in the contract between the construction company and the Carey Board. The timber has lasted exceedingly well. It is quite questionable if the concrete would have lasted as long when the wear due to shifting gravel is taken into consideration and also the destructive action of frost.

RIGHTS-OF-WAY OVER STATE LAND

All rights of way of this character have been obtained, with the exception of one which is now in the process of being purchased.

WATER SUPPLY

Heretofore it has been considered and, I believe, rightfully so, that there would always be a certain amount of land which do not call for water every year. This would cover lands not farmed, land occupied by farmers who do not use water on all or part of their farms, lands not properly cared for requiring cultivation to the extent that the time of the occupant did not permit an entire irrigation, lazy, indolent tenants and also lands occupied by roads, buildings, etc. Heretofore, the construction company has been allowed 15% as a fair estimate of the amount of land so classified. This was reduced to 10% by the Carey Act Inspectors of the Federal Government. However, they recognized the practicable equity and truth of the factor in our water supply. Time and experience has proven that hardly any agricultural units of 80,000 acres is ever used in its entirety every year. To ignore these conditions would not be using the available water supply to its maximum efficiency nor would it be good economics in the State of Montana where there is more land than the available water supply can ever serve. I do not believe it is equitable or right to consider that this excess water will be used eventually by the farmers through selling additional water stock after the construction company has turned the Project over to them. The water rights are the only stock in trade the construction company has. It has put into this Project over $6,000,000.00 and stands a very slim chance of getting a small percentage back. This outside money has all been spent in Montana. The efforts at colonization have increased the population of the State. Through the expenditure of this money the taxable wealth of the State has been raised. Yet, in the face of these facts do you believe the settlers on the Project should be given the advantage of any additional water there may be in time to come? Do you believe this privilege should be taken away from the construction company which has made the present status of this Project possible? If you do, I cannot agree with you. Matters of such importance as this should be seriously considered before a decision is reached as to the limit which should be placed on the amount of water stock which can be sold on the Project. I believe the construction company should be given the privilege of selling water stock in addition to any limit in the irrigable acres on the Project providing an increase in the amount of water supply should be found later through an increase in duty or by any other means which would be equitable and right. For these reasons I contend the item of non-use should be taken into consideration in computing the acreage that can reasonably be considered as possible to supply with water each year.

In this region irrigation can only be considered as a supplement to precipitation. In your analysis you have taken one inch of precipitation as equivalent to two inches of irrigation water. I have searched for a basis for this assumption, but have been unable to locate an experiment or an authority who recommends this proposition. In the experiments on the duty of water conducted by Doctor Widsoe of Utah and Mr. Don Bark, formerly of Idaho, they considered these two forms of moisture as equivalent. There is, of course, waste from irrigation and also loss through evaporation and deep percolation, but the same conditions occur with precipitation. A rain of an amount sufficient to materially affect the growing crops is partially wasted in run-off in coulees and draws. Evaporation takes effect as soon as the precipitation ceases and the clouds break away. Cloudy weather, of course, decreases the amount of evaporation, butthis condition also retards the growth of the crops due to a decreased amount of sunlight and heat. Deep percolation takes place with rain as well as with irrigation. With these natural conditions in mind and also the findings of recognized authority I believe that precipitation and irrigation water should be given equal weight in computing the water supply for the Project.

As to the adjudication of water rights this was never contemplated in the contract. The contract gives the majority of the water rights involved as they stood originally. In this case as in the others the construction company has considered the standing of the water rights as good and sufficient for the purpose intended and have made their expenditures with this in mind. I do believe that if the State of Montana were financially able to settle the title to all water rights capital would be more inclined to invest in future undertakings in the State which would be dependent on water in the streams for their inception, development and realization.

C. E. Atwood
Chief Engineer,
Valier Montana Land & Water Co.

considered if we were determining the proper duty of water. However, the duty of water for this project is fixed by the contract at "one and one-half acre feet per acre, each and every year". This is the provision under which this land was patented to the State and under which the settler has bought his water stock. A redetermination of this duty cannot be properly applied atthis time.

Mr. Atwood speaks of "excess water". I can see no possibility of an excess of water over a period of years. We have a reliable record of stream flow over a period of 21 years. This shows all the water available for the project. With fair allowances for prior rights and for unpreventable losses, the net average supply remaining is less than required for 1½ acre feet per acre for 80,000 acres. Mr. Atwood rightly points out that the Valier Company and its predecessors have been of great value to the State thru making this development. I believe, too, that they have acted in good faith in their relations with the Carey Land Act Board. This should be considered and they should not be persecuted, but should be given the benefit of all reasonable doubt and should be favored where this can be done without breaking faith with other parties interested. In line with this thought, it was suggested in the report that the Board consider allowing the Company to sell stock for somewhat more than the strict limitation to 1½ acre feet per acre. However, to allow them to sell stock for more than a fixed reasonable total would be to break faith with the Government and with the settlers. Carey land was patented to the state on condition that the project be limited to 80,000 acres and the settlers bought land and water stock with the understanding that each share could be reasonably expected to furnish 1½ acre feet per season. Were the construction company allowed, -as suggested by Mr. Atwood, -to "sell water stock in addition to any limit", (the limit persumably to be fixed by the company), the present settler's water right could be reduced indefinitely, depending only on the company's ability to sell stock. Should additional water supply be developed by the Valier company or by anyone else, such supply might be distributed thru the system of the Pondera County Canal and Reservoir Company for the benefit of the one developing such supply. However, the whole flow of Birch Creek, -except prior rights, and the normal flow of Dupuyer Creek and Dryfork will belong to the Pondera Company. Additional supply can be obtained only by storing the flood waters of Dry Fork or Dupuyer Creek, or by diverting from some other water-shed. It is not understood that the Valier Company contemplates doing any of these things.

Mr. Atwood questions my analysis of water supply, especially the assumption of two inches irrigation being equivalent to one inch of precipitation. This assumption is based on no precedent or authority except my own experience and observation. Under the methods of irrigating now used and likely to be used on the Valier project, it will require six inches of irrigation water for one irrigation, and it is a good thorough irrigation which will wet the soil as effectivly as a slow two inch rainfall. It is true that a quich shower will be less effective, but most of our precipitation comes in slower, more effective storms. This assumption would be applied only under the special conditions of this project: Different soil conditions, and especially different methods of applying water would materially change it. However, the above assumption and the analysis based upon it are merely for the purpose of pointing out the service the available water supply can be expected to render to 80,000 acres. This analysis does not affect the amount available nor the question of the number of acres that amount will reasonably serve with 1½ acre feet each and every year, which is the duty of water fixed by the contract, the duty on which land and water sales to settlers are based.

The question of adjudication of water rights is referred to the Board as a

Appendix to Report on Valier Carey Land Act Project.

As an appendix to the report on the Valier Carey Land Act project, I submit a copy of arguments by Mr. C. E. Atwood, Chief Engineer of the Valier Company and the following comments on those arguments:

LAKE FRANCIS DAM

Mr. Atwood's argument applies only to the recommendation of provision for double control gates on the outlets. I believe this office has never approved the present condition of the upstream face of the dam and the riprap. The requirement for a coping wall or other additional freeboard or wave protection was made a condition of approval by the Government of patent to Carey lands and so must have been required by this office heretofore. This requirement should be enforced by the state as a matter of public safety, even if no Carey lands were involved.

The plans for reconstruction of the outlet in 1911, -at which time the original double control was eliminated, -were approved, I believe, by the State Engineer at that time, so, for this item, Mr. Atwood's contention is properly based. The fact remains that single control in this situation is improper design and good practice will require that double control be installed at the first practicable time by the Pondera County Canal and Reservoir Company. Whether the Valier Company should stand part or all of the cost of such installation as a condition to acceptance by the State is rather a judicial question which is submitted for consideration of the Carey Land Act Board. The report also recommends that the Valier Company stand thecost of inspection and possible repair of the outlet pipes. This item can hardly be affected by any previous approval of the State Engineer.

"P" SYSTEM

After transfer of the project, Carey Act land owners will be stockholders on the same basis as owners of "Pondera" or other water right lands, and will be liable for their pro rata share of costs for repairs, reconstruction and maintenance necessary to give all shareholders reasonably equal service. Any faulty or insufficient structure is a liability to all lands alike. For this reason, I believe the "P" flume and wasteway should be required to be put in the same condition as if they directly served Carey Lands.

"B" CANAL

My understanding has been that the State Engineer approved plans for timber drops in the main supply canal as temporary, more or less experimental, structures. It would be an unreasonable interpretation of the contract to allow less permanent structures on this largest and most important canal than are required for all other canals of the project. In many cases, part timber structures might be approved as being actually more permanent than all concrete but many of these drops are strictly temporary in character and provision should be made for their eventual replacement with more permanent form of construction.

"WATER SUPPLY"

I cannot concede Mr. Atwood's contention that water supply should be figured for any acreage less than the total amount of water stock finally sold. The man who, properly, has all land under cultivation for which he owns water stock, is entitled to full service. The man who owns water stock for land that cannot be irrigated should transfer that stock to land that can use the water. I concede that there will be some seasonably unused land and water right, and this would be legal, rather than an engineering question. However, Mr. Atwood remarks that this was never contemplated by the contract. This may be, but the constructing company planned to have these rights adjudicated and spent considerable money preparing for trial and, I understand, was ready to file suit, but postponed action when it was found that the Federal Government would allow patent to the Carey lands without adjudication. So the constructing company has at some time, contemplated adjudication as a necessary part of the completion of the project.

J B James.

State Engineer.
Secretary, Carey Land Act Board.

Analysis of Water Supply for Valier Project.

Based upon (1) Water supply from Birch and Dupuyer Creeks only as shown by gaging station on Birch creek above project diversion and gaging station on Dupuyer just above diversion. (Early records for Dupuyer Creek were made at Dupuyer and miss some runoff which should be included.) Winter flow of Dupuyer Creek is modified by taking off half of December and all of January and February except where actual lake levels show there was a flow during these periods.

(2) Capacity of supply canals, Birch to Dupuyer Creek, 700 sec. ft., Dupuyer Creek to Lake Francis, 900 sec. ft.

(3) Total canal losses 15% applied to net requirements.

(4) Reservoir evaporation losses, 15 inches per annum in Sweift Dam and 22 inches in Lake Francis in months as follows; Oct. Nov. Dec. Jan. Feb. Mar. Apr. May, June, July, Aug. Sept Total L.F. 1.10 1.10-0.88-0.44-0.66-0.88-1.10-2.20-2.42-4.62-3.96-2.64-22.00---S.D. 0.75-0.75 0.60-0.30-0.45-0.60-0.75-1.50-1.65-3.15-2.70-1.80-15.00 applied to the actual lake surface as indicated by tabulation of assumed operation.

(5) Seepage loss from Lake Francis 150 acre feet per month outside of irrigation season.

(6) Prior rights in Birch creek assumed at 15% of project requirements, plus 500 acre feet for Birch Creek per month outside of irrigation season. This was modified by limiting irrigation use of prior rights to not over 5,000 acre feet and not under 530 acre feet in any one month, and not over 20,000 acre feet in any one year.

(7) Project requirements for 80,000 acres based on amounts of irrigation necessary to bring effective moisture to 20 inches per annum, assuming two inches of irrigation equal to one inch rainfall or effective moisture. This method applied to the tabulated rainfall for 21 years (See Tables 1 & 2.), gives an average irrigation requirement of 15 inches per year. This 15 inches is assumed to be distributed by months as shown on table (1), applying to each month the amount of irrigation needed to bring the total effective moisture for that month to the assumed optimum, considering the precipitation for May as including the total from Oct. 1st to May 31 st. These assumed ideal amounts of effective moisture are taken as follows: Oct. 1st to May 31st, (determining May irrigation requirement), 6.7, June 4.7, July 4.1, Aug. 2.25, and Sept. 2.25 inches, Total 20.00 inches.

In table 1, these net requirements of effective moisture are worked out for each month with the net acre feet required. In table 2 are shown the gross requirements, which are the net requirements plus 15% assumed canal and distribution loss and further modified by assuming that not more than 50,000 acre feet and not less than 3,500 acre feet would be used in any one month.

On these assumptions, a tabulation was carried through (Table 3) showing assumed ideal operation by months from Oct. 1st, 1908 to Oct. 1st, 1929. From this tabulation were determined losses from reservoirs, -seepage and evaporation, and losses on account of limited supply canal capacity and limited reservoir capacity. These losses thus determined were then used in a tabulation of operation by years as shown in table 4 (a). For comparison, a tabulation was also made showing operation by years, assuming full contract use each year. For this latter tabulation nearly the same reservoir losses were used as determined by the monthly operation under the lesser use. This is slightly erroneous, as the reservoir losses would have been somewhat different, -probably less. Approximate correction was made however, for difference in losses due to limited capacity of

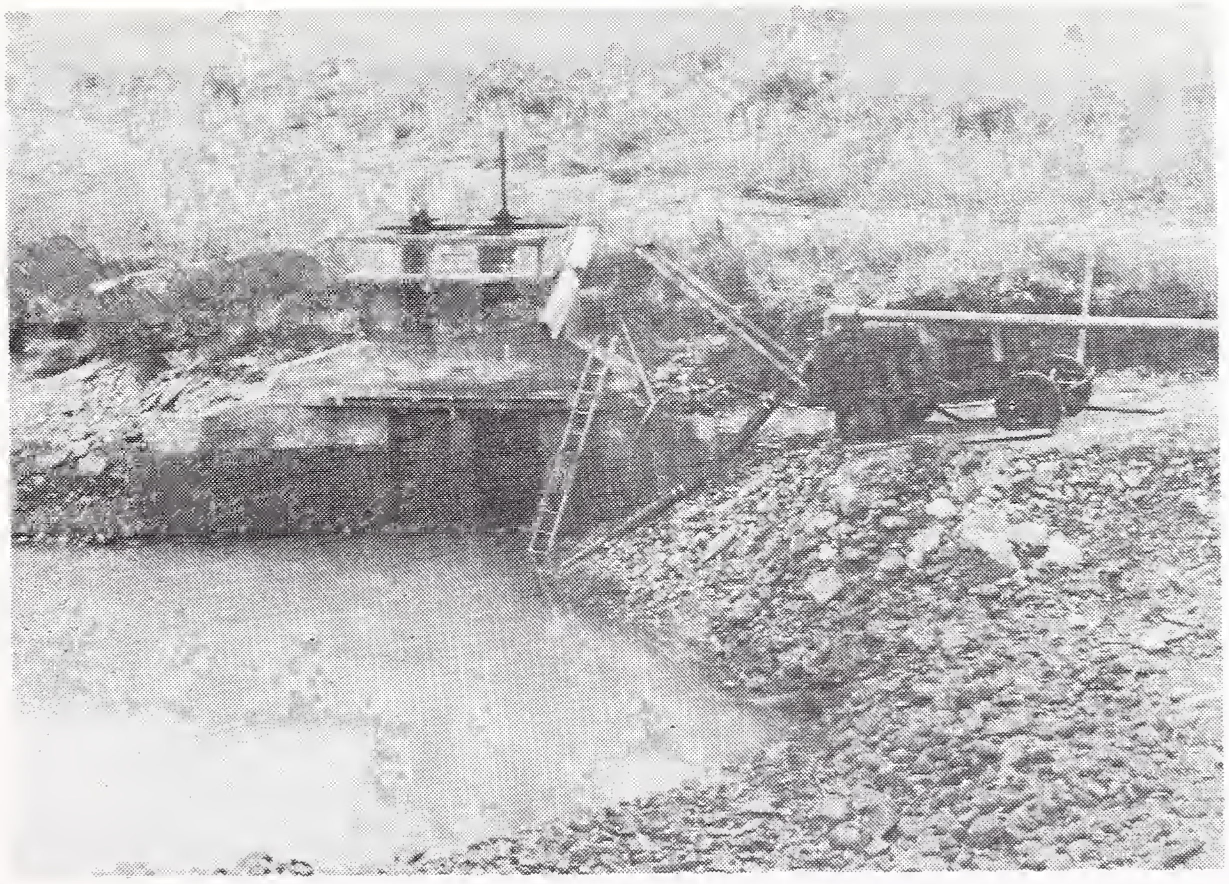
canals and reservoirs.

Study of this tabulation, (Table 4(a)), shows there would have been serious shortage in two years, 1919 and 1921, with slight shortage in 1910, 1914, 1920 and 1922. However, in 1910 20.7 inches were available, 2.7 inches above contract amount, 21.8 in 1914, contract amount of 18 inches in 1920 and, in 1922, only 11.9 inches, six inches below contract, but nearly up to requirement based on rainfall. In the dry year of 1918, 21.7 inches were available, 3.6 inches above contract. Had use in 1918 been limited to contract, -120,000 acre feet net, 138,000 acre feet gross, 28,500 acre feet more would have been available in 1919 making possible use of 94,800 acre feet, 43,300 short of contract amount.

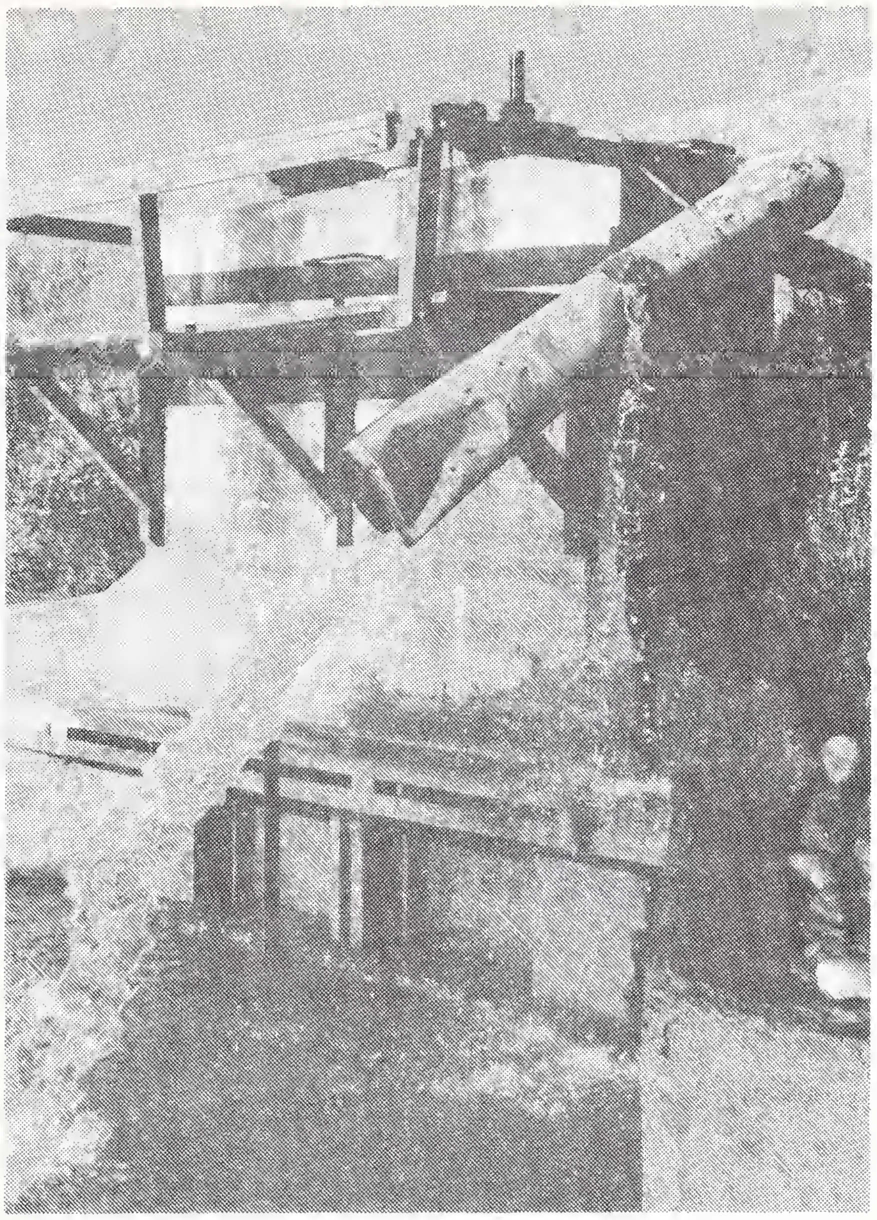
The other tabulation; table 4(b), based on contract requirement of 120,000 acre feet net, -138,000 gross, -each and every year, and prior right use of 20,000 acre feet each year shows shortage on 13 of the 21 years with about the same service in 1919 and 1921

The first tabulation gives an average project use of 103,620 acre feet, 13.5 inches net on 80,000 acres or 15 inches on 71,960 acres. The second tabulation gives an average available gross of 118,860 acre feet, net 15.4 inches on 80,000 acres, or 18 inches net on 68,900 acres.

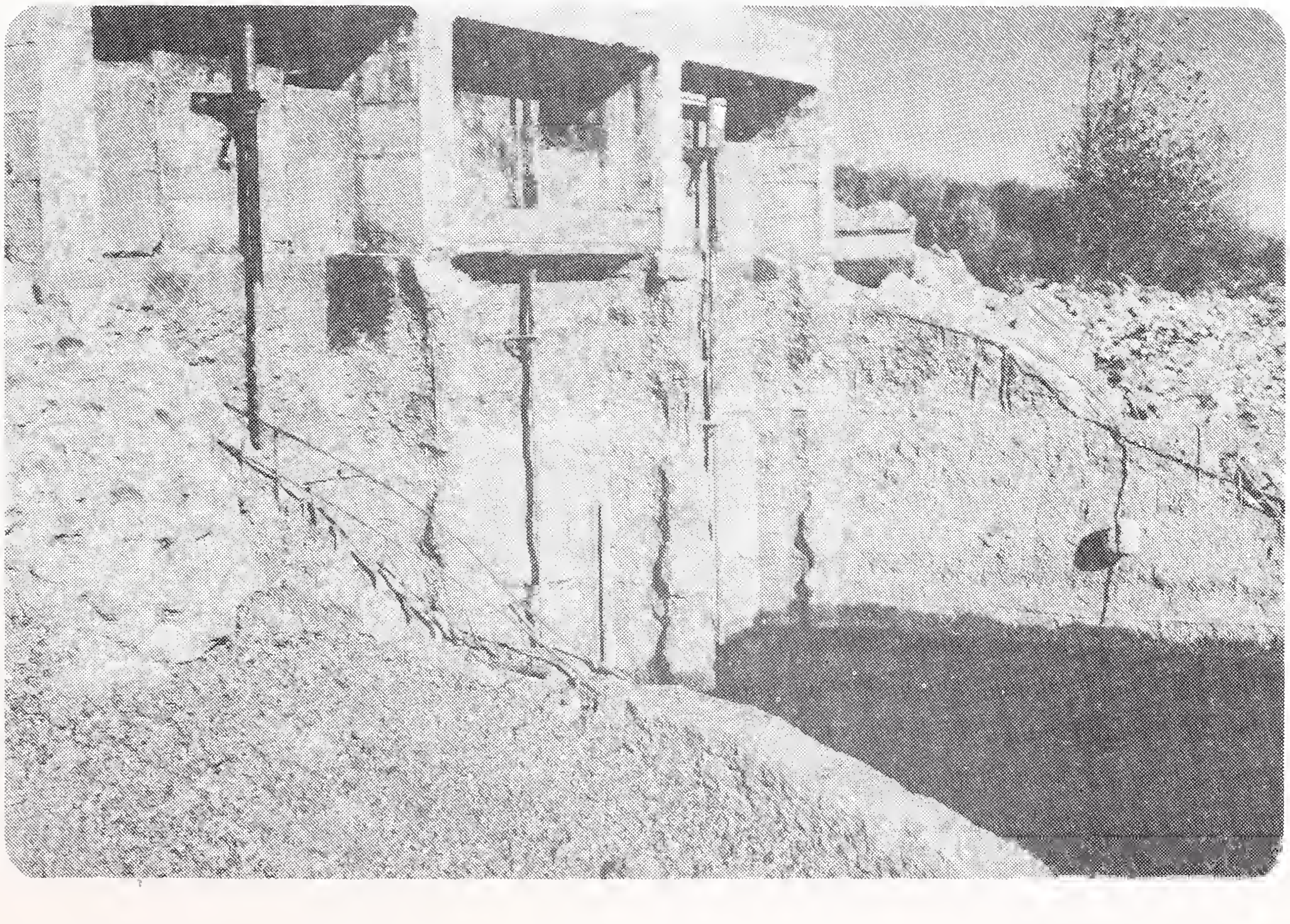
(PHOTO 1) UNNAMED DIKE SOUTHEAST OF VALIER



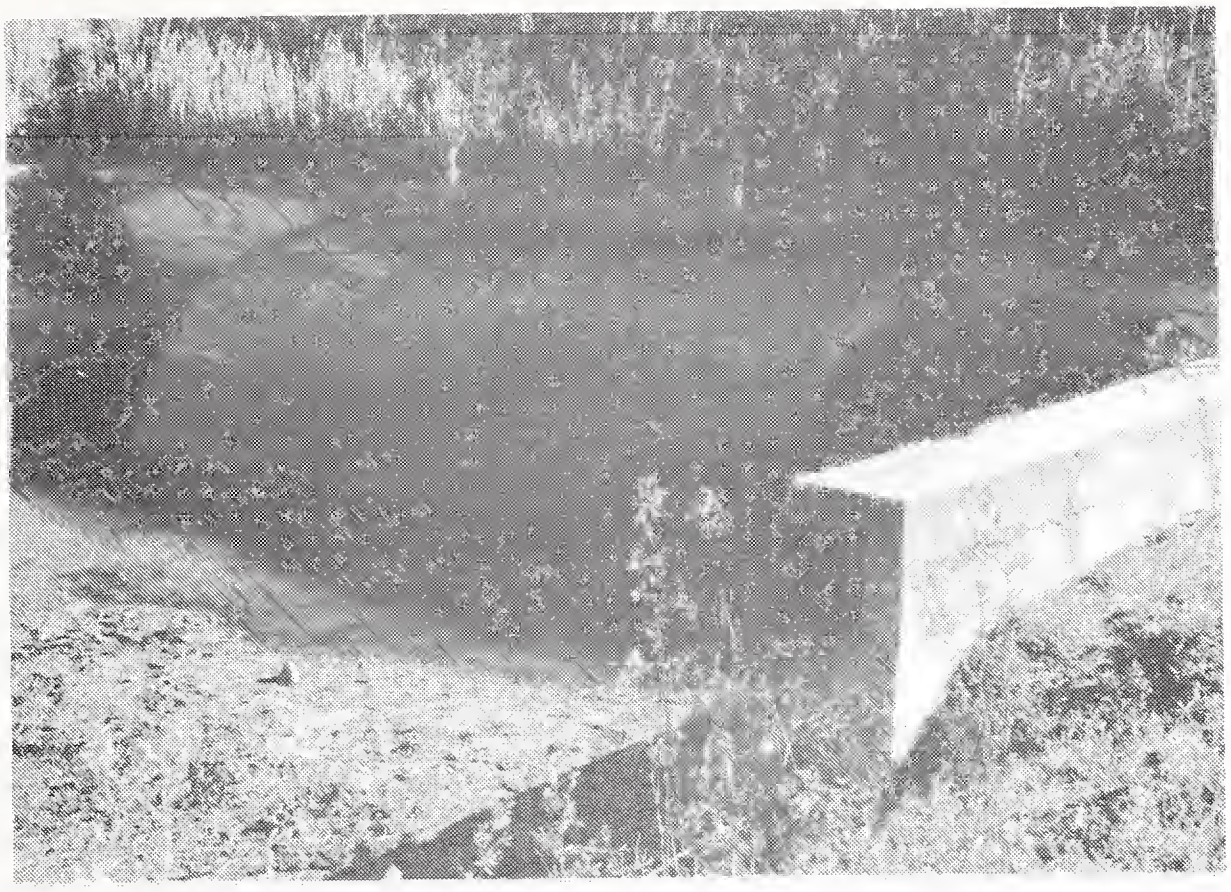
(PHOTO 2) EAST DAM - OUTLET STRUCTURE



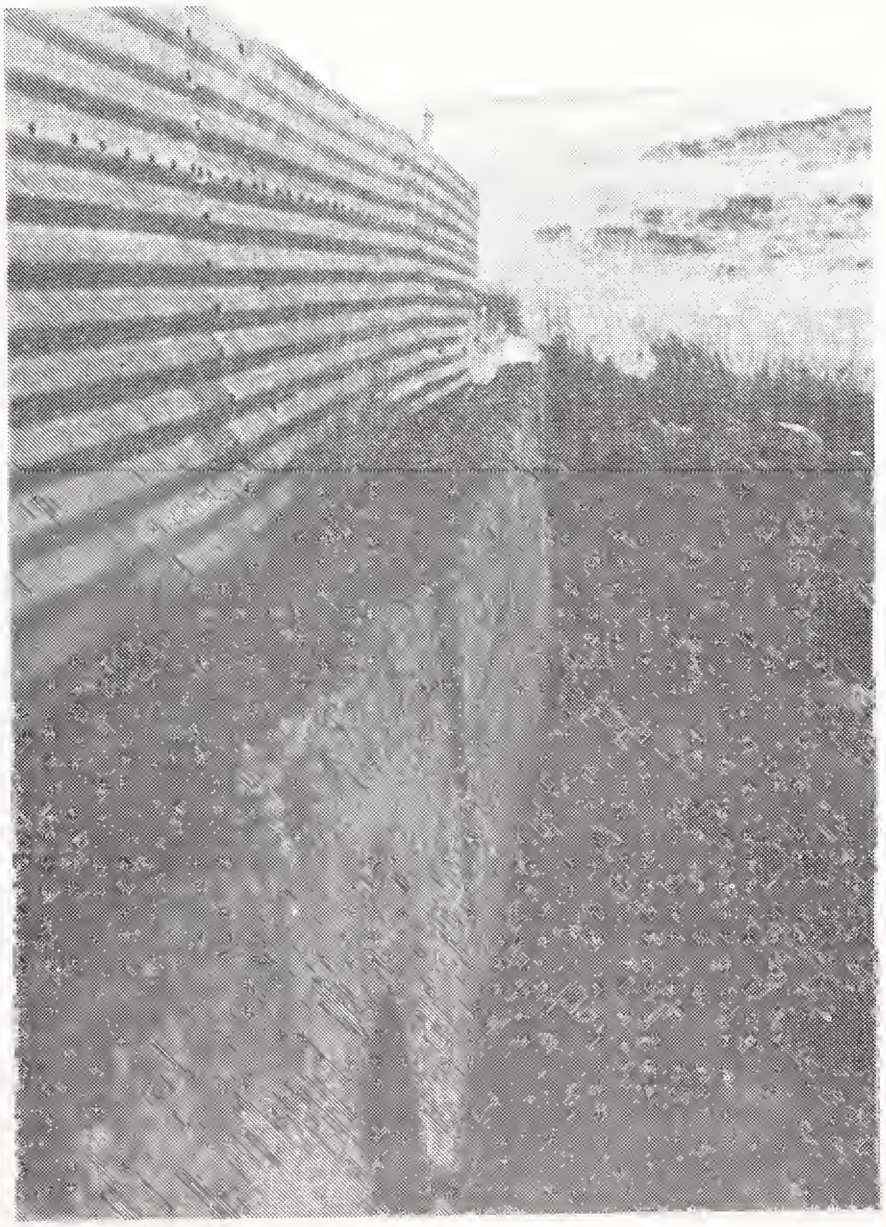
(PHOTO 3) EAST DAM - OUTLET STRUCTURE
OVERFLOW PIPE



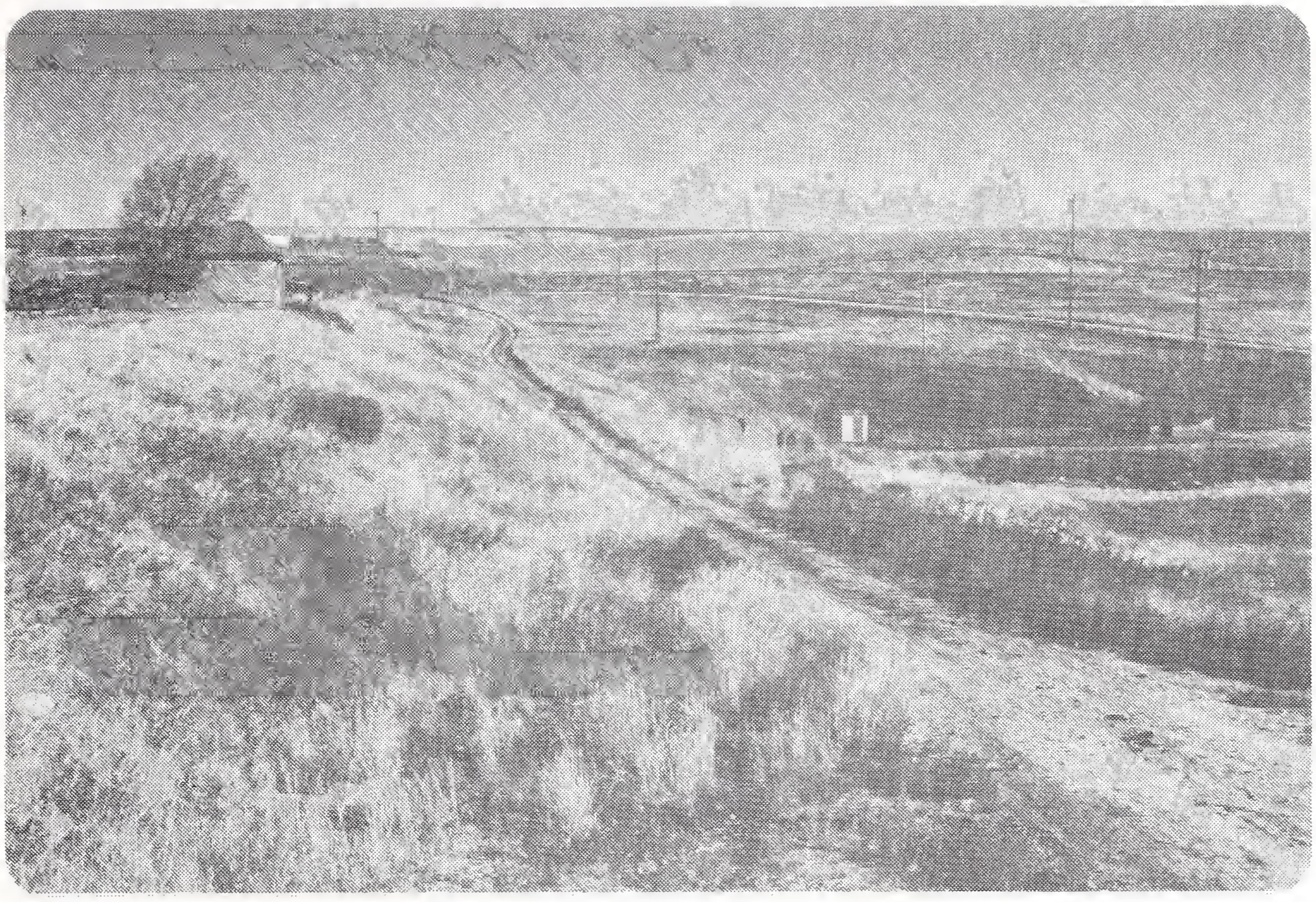
(PHOTO 4) NORTH DAM - INLET STRUCTURE



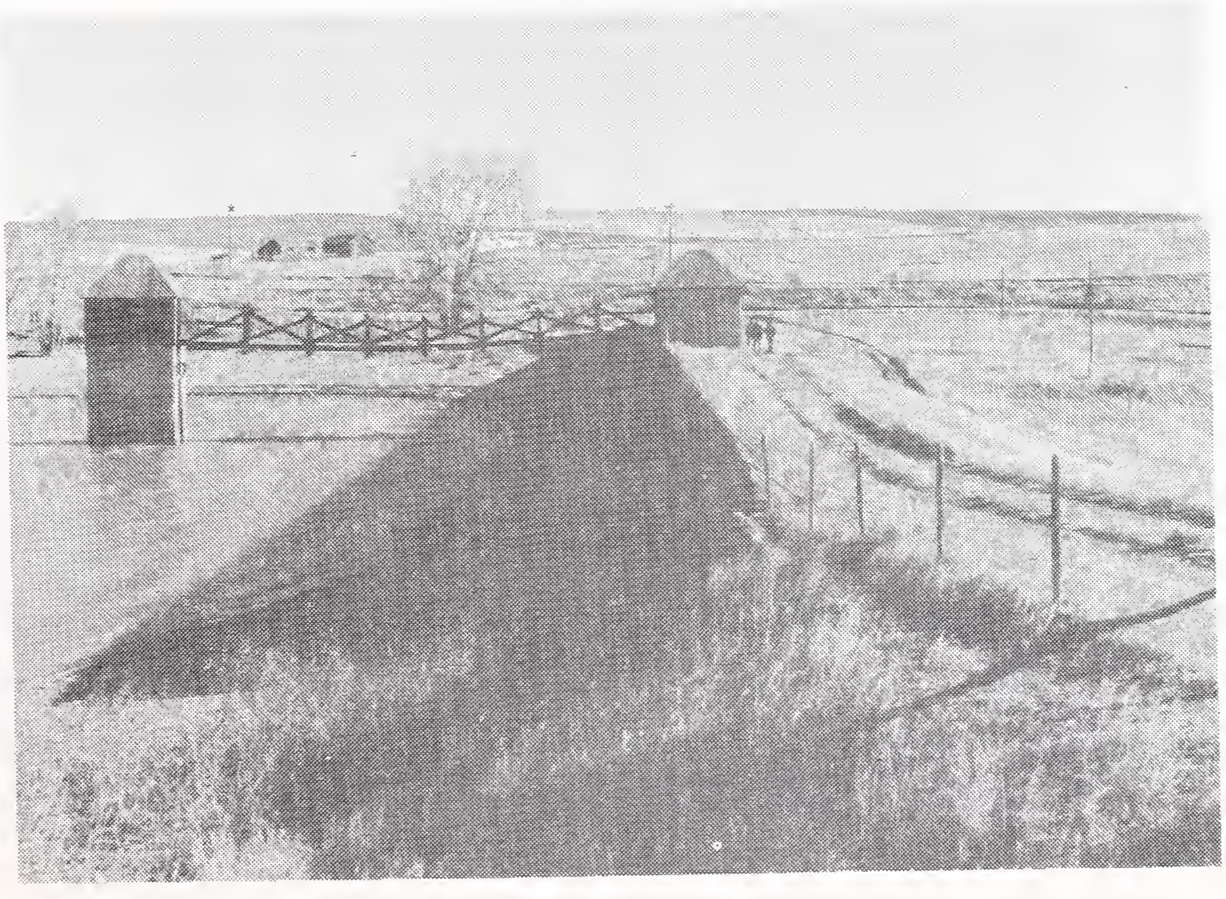
(PHOTO 5) NORTH DAM - OUTLET STILLING POOL



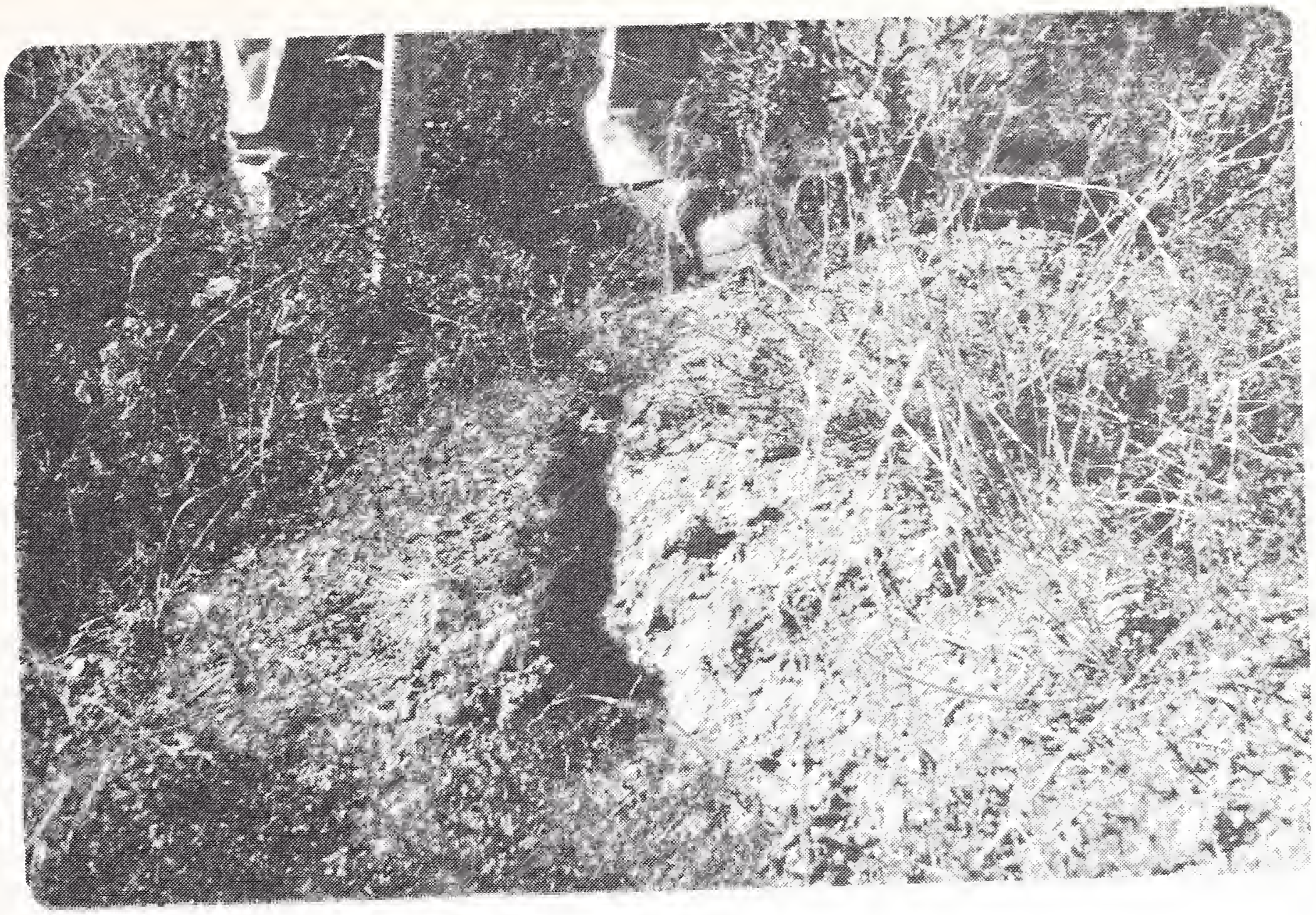
(PHOTO 6) EAST DAM - METAL PARAPET WALL



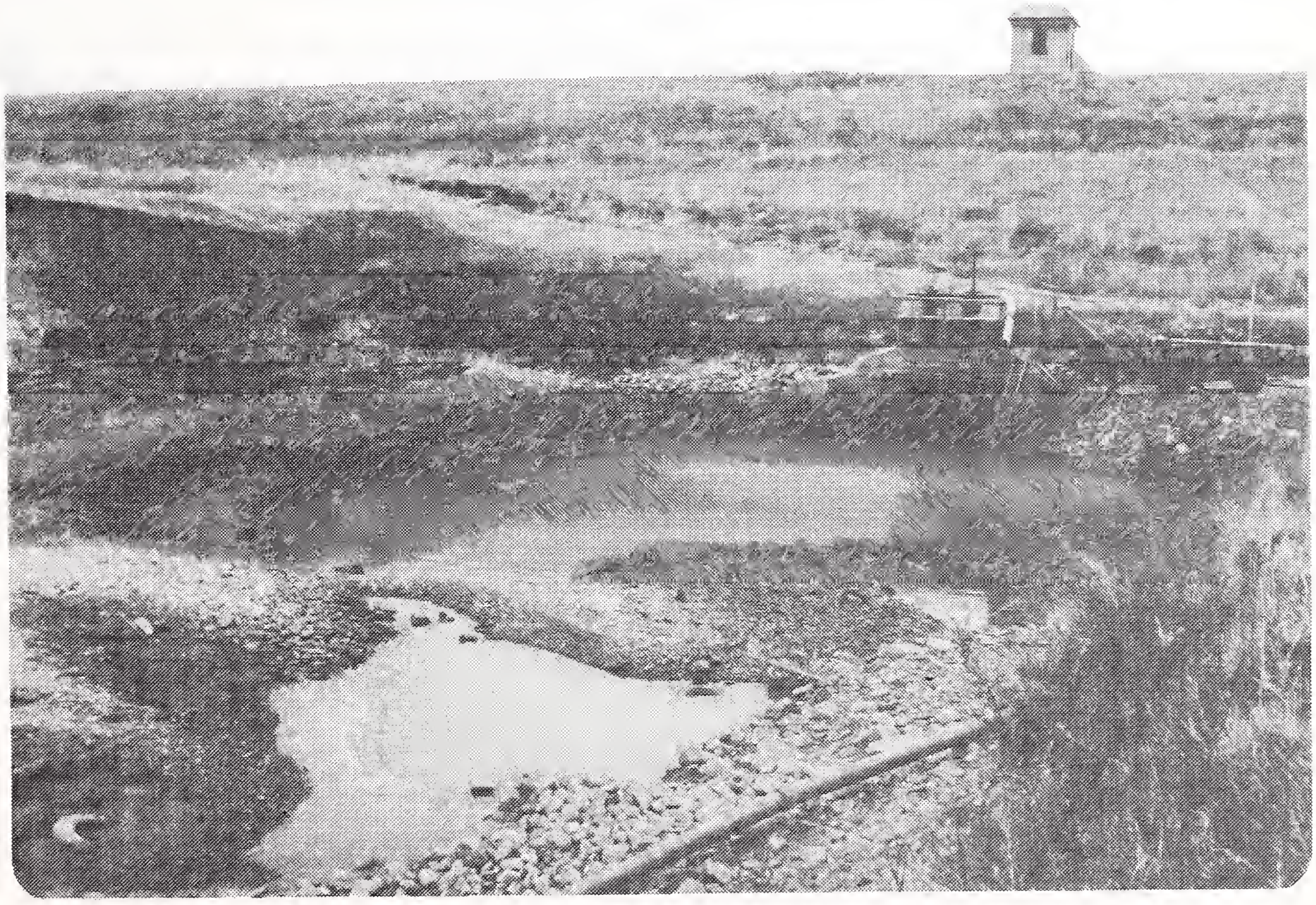
(PHOTO 7) EAST DAM - DOWNSTREAM SLOPE



(PHOTO 8) EAST DAM - UPSTREAM SLOPE

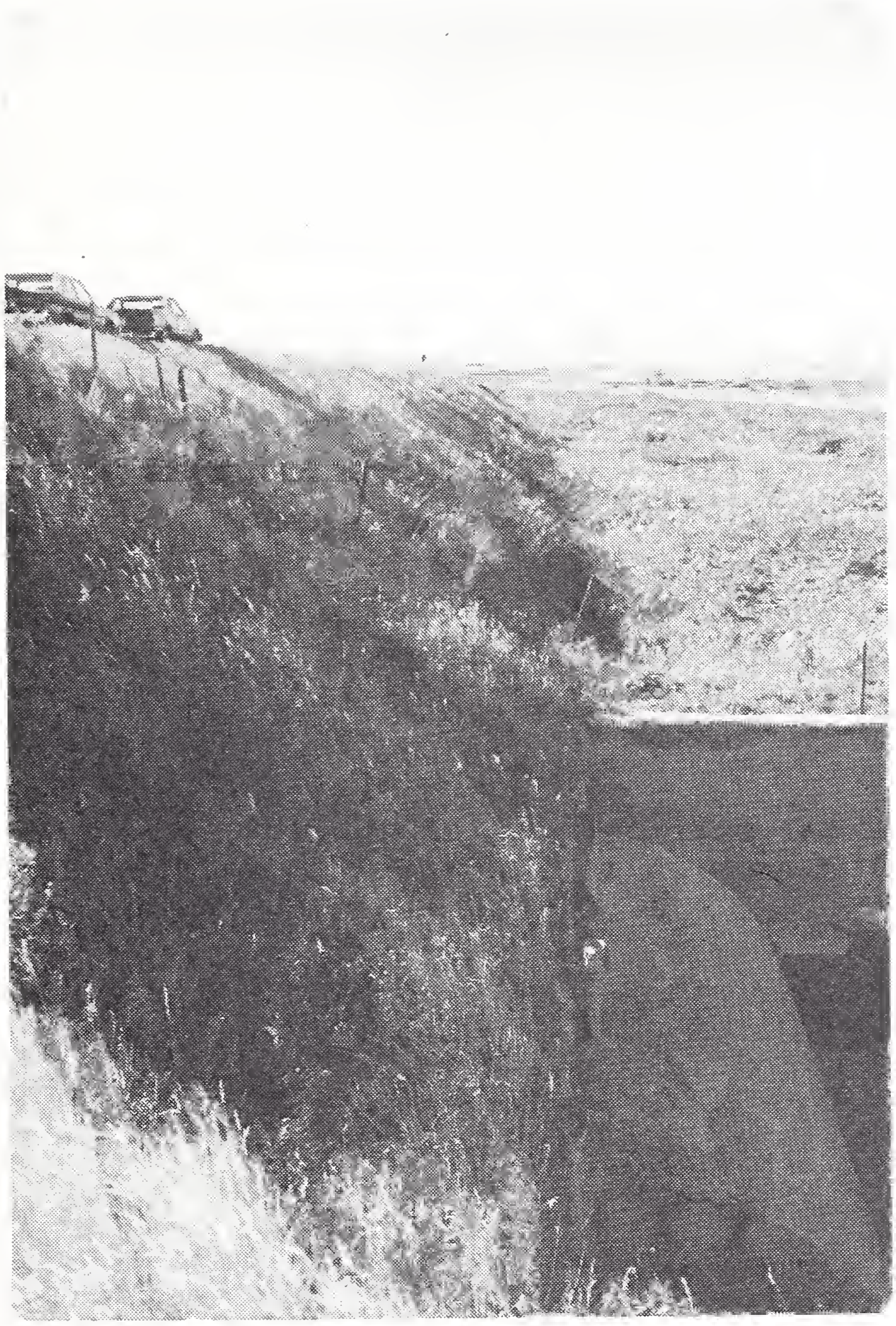


(PHOTO 9) EAST DAM - DOWNSTREAM SLOPE CRACK



(PHOTO 10) EAST DAM - EROSION ALONG DOWNSTREAM TOE

(PHOTO 11) NORTH DAM - UPSTREAM SLOPE



(PHOTO 12) NORTH DAM - DOWNSTREAM SLOPE

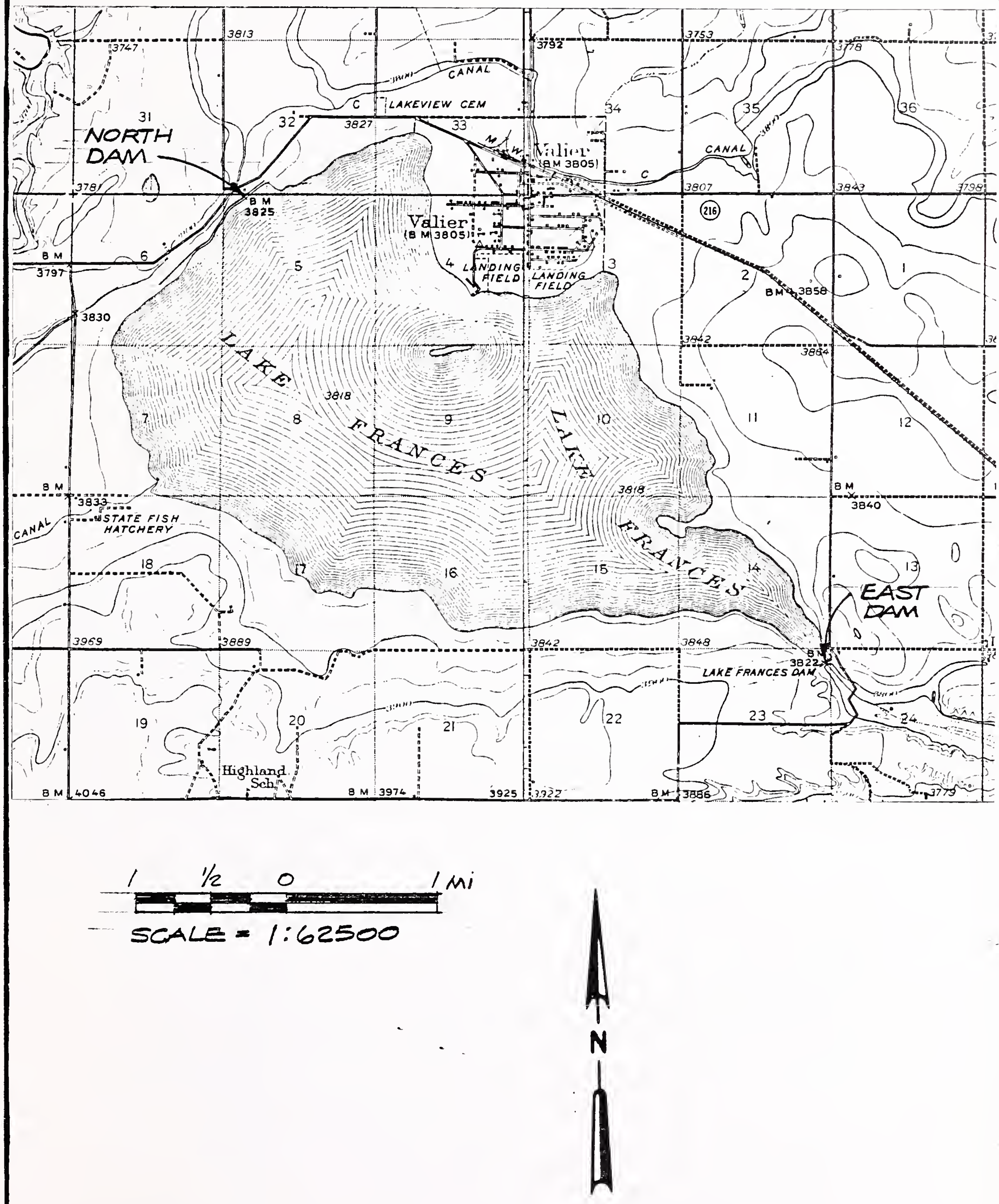


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PLATE 1

LAKE FRANCES
DAMS & RESERVOIR
VICINITY MAP

CH2M HILL

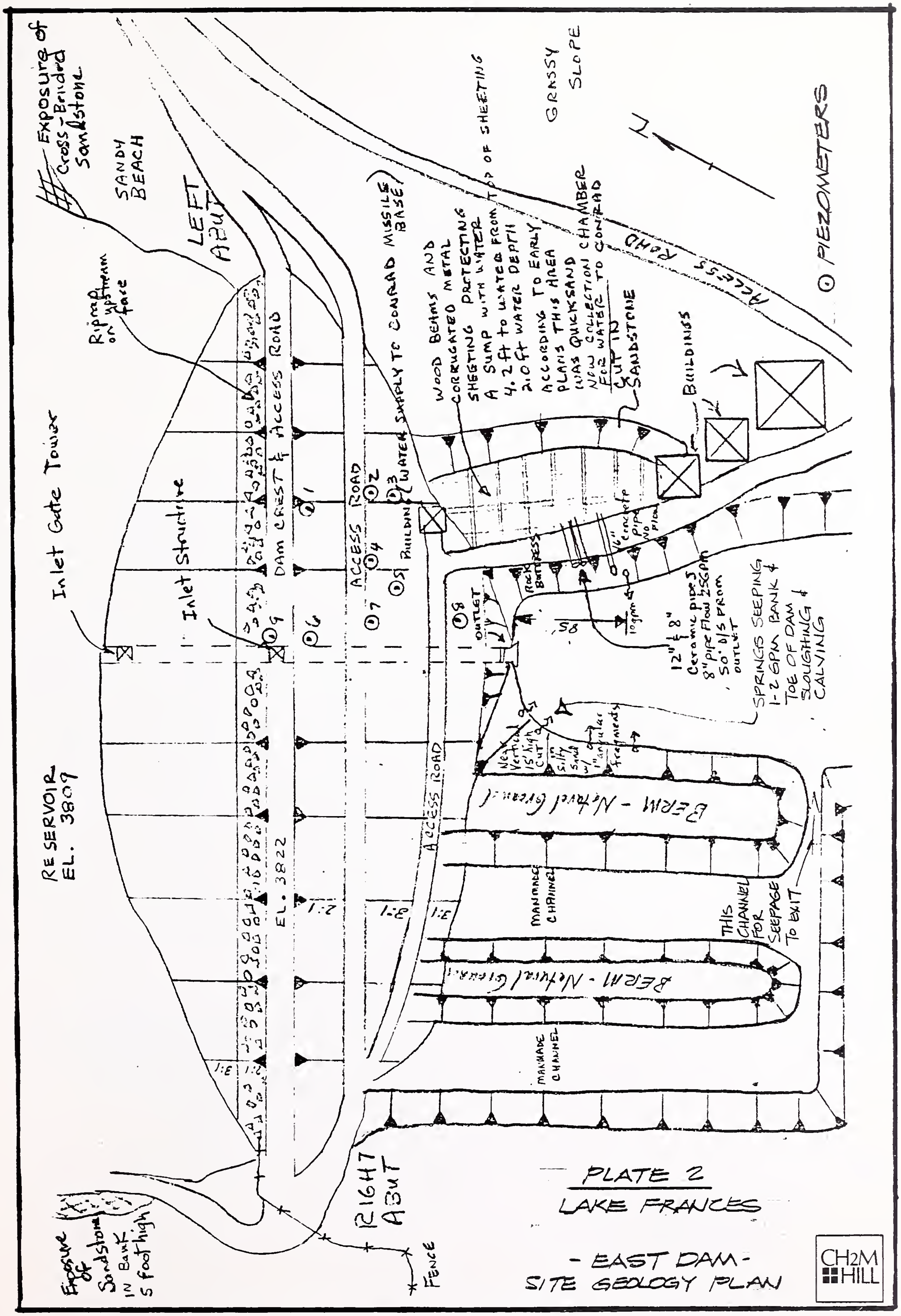

Exposure of Cross-Bedded Sandstone
SANDY BEACH
LEFT ABUT
Riprap on upstream face
Inlet Gate Tower
Inlet Structure
RESERVOIR EL. 3809
EL. 3822
DAM CREST & ACCESS ROAD
ACCESS ROAD
WATER SUPPLY TO CONRAD MISSILE BASE
BUILDING
OUTLET
ACCESS ROAD
1:3
3:1
GRASSY SLOPE
N
PIEZOMETERS
ACCESS ROAD
WOOD BEAMS AND CORRUGATED METAL SHEETING PROTECTING A SUMP WITH WATER 4.2 FT TO WATER FROM TOP OF SHEETING 2.0 FT WATER DEPTH
ACCORDING TO EARLY PLANS THIS AREA WAS QUICKSAND
NEW COLLECTION CHAMBER FOR WATER TO CONRAD
CUT IN SANDSTONE
BUILDINGS
Rock Buttress
6" Concrete Pipe No Flow
10 gpm
.58
12" & 8" Ceramic pipes 8" pipe flow 25 gpm, 50' D/S FROM OUTLET
SPRINGS SEEPING 1-2 GPM BANK & TOE OF DAM SLOUGHING & CALVING
Near Vertical 15' high cut in silty sand w/ angular fragments
BERM - Natural Ground
MANMADE CHANNEL
THIS CHANNEL FOR SEEPAGE TO EXIT
BERM - Natural Ground
MANMADE CHANNEL
RIGHT ABUT
Exposure of Sandstone in Bank 5 foot high
FENCE
1 2 3 4 5 6 7 8 9

PLATE 2
LAKE FRANCES

- EAST DAM -
SITE GEOLOGY PLAN

CH2M HILL

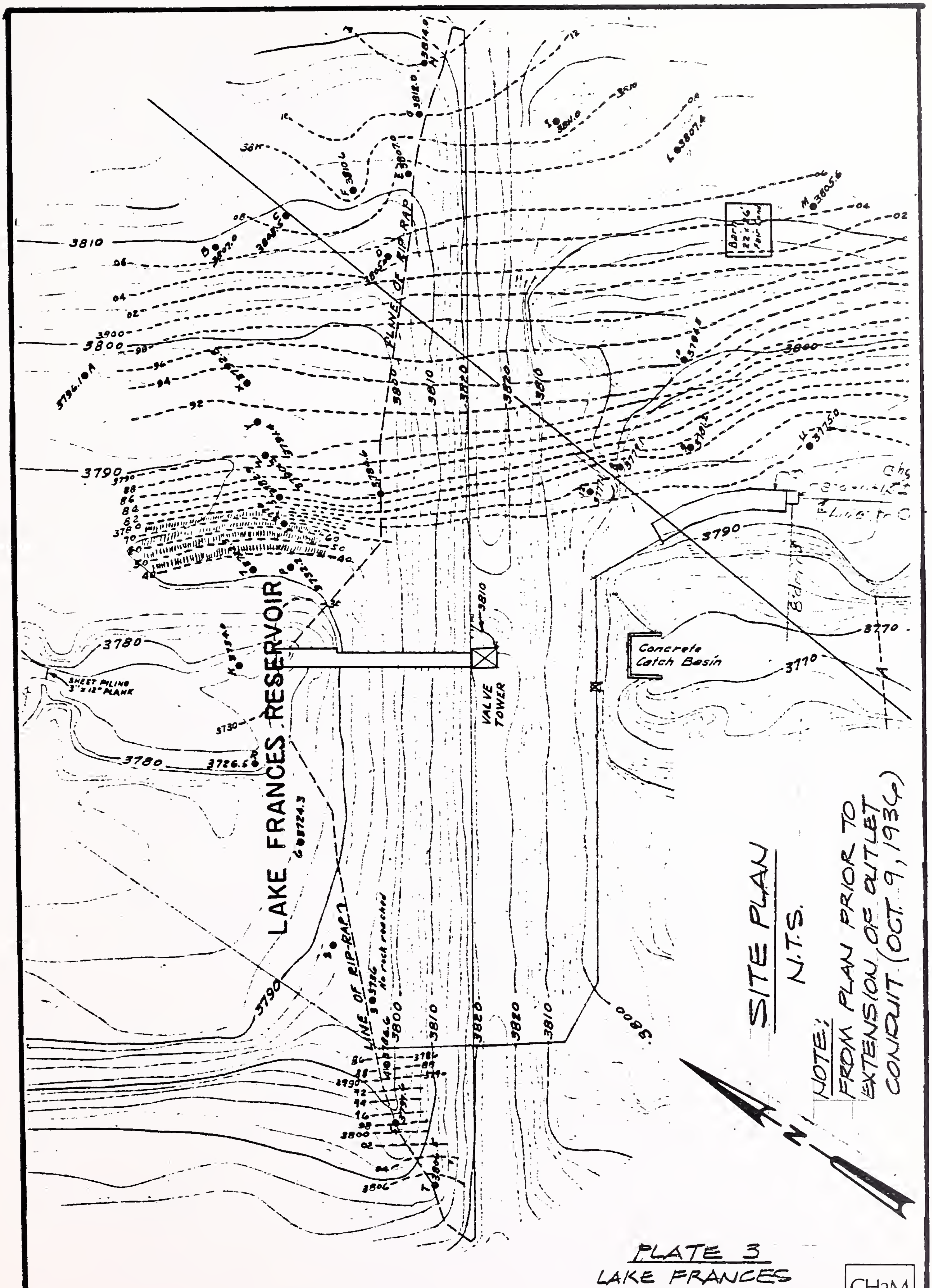


PLATE 3
LAKE FRANCES

CH2M HILL

SITE PLAN - EAST DAM

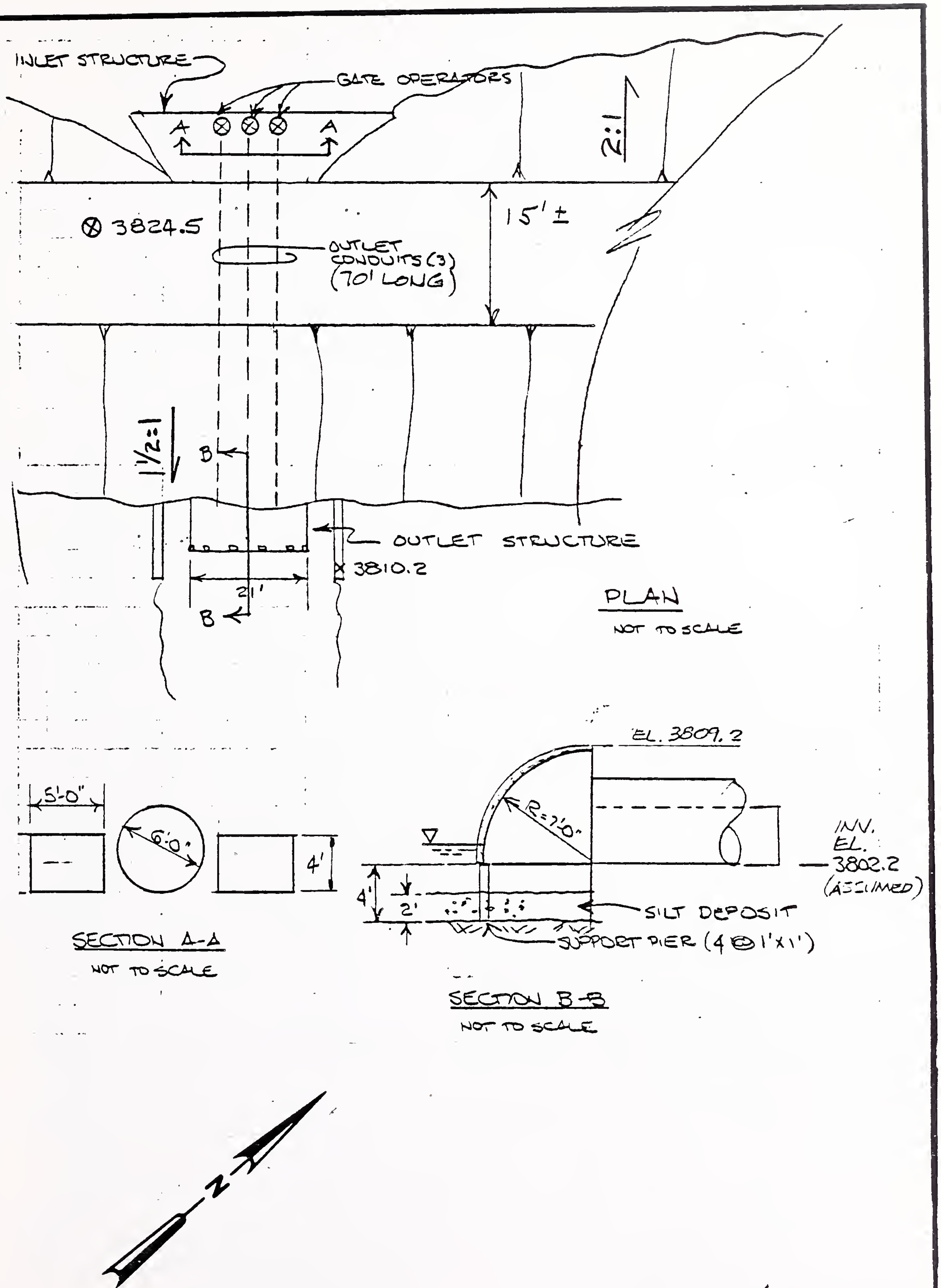


PLATE 4

LAKE FRANCES
SITE PLAN &
OUTLET WORKS

CH2M
HILL

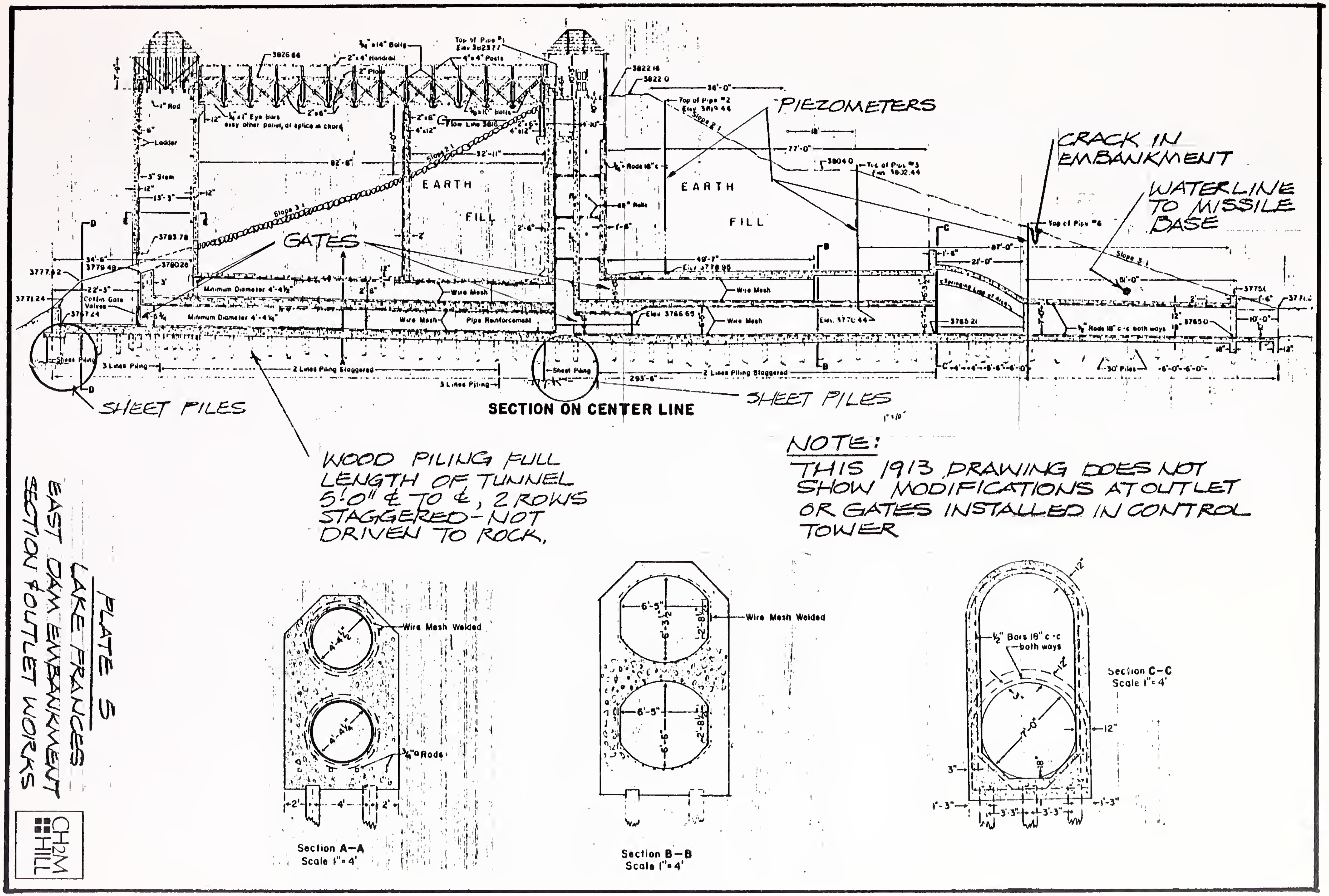
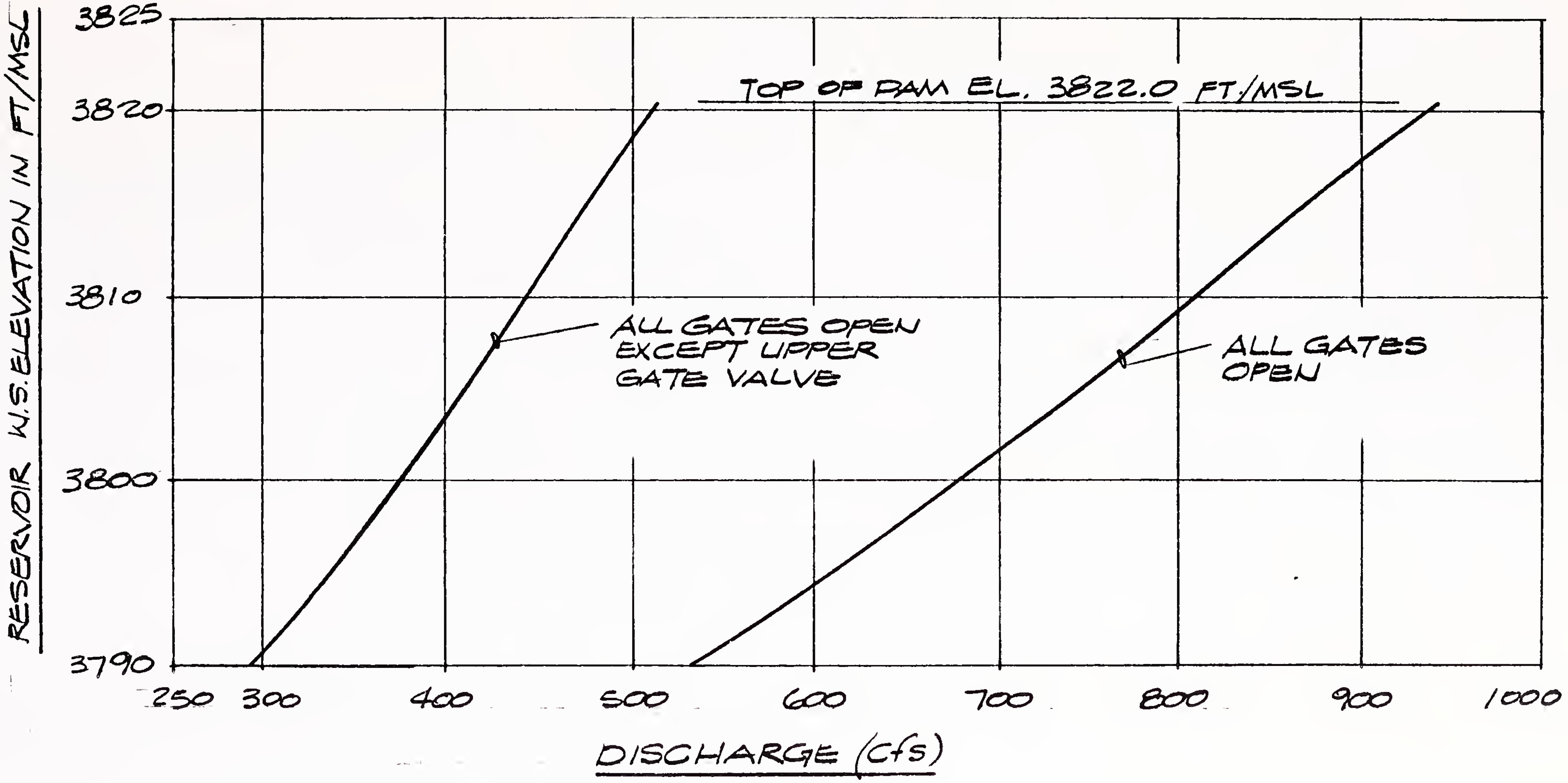


PLATE 5

LAKE FRANCES

EAST DAM EMBANKMENT
SECTION & OUTLET WORKS

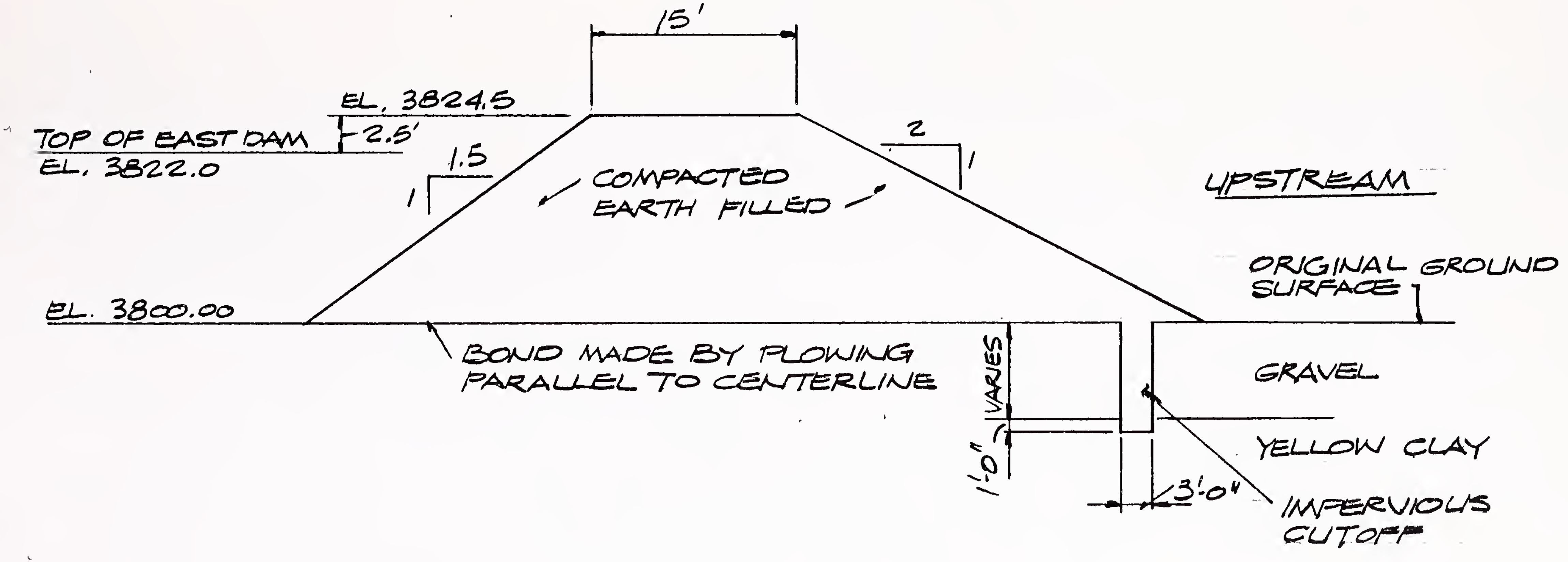
CH2M HILL



NOTE:
THIS CURVE INDICATES THE MAX. POSSIBLE OUTLET DISCHARGE AND IS NOT INTENDED TO IMPLY THAT OUTLET WILL SAFELY PASS SUCH FLOWS.

PLATE 6
LAKE FRANCES
EAST DAM OUTLET
RATING CURVES

CH2M HILL



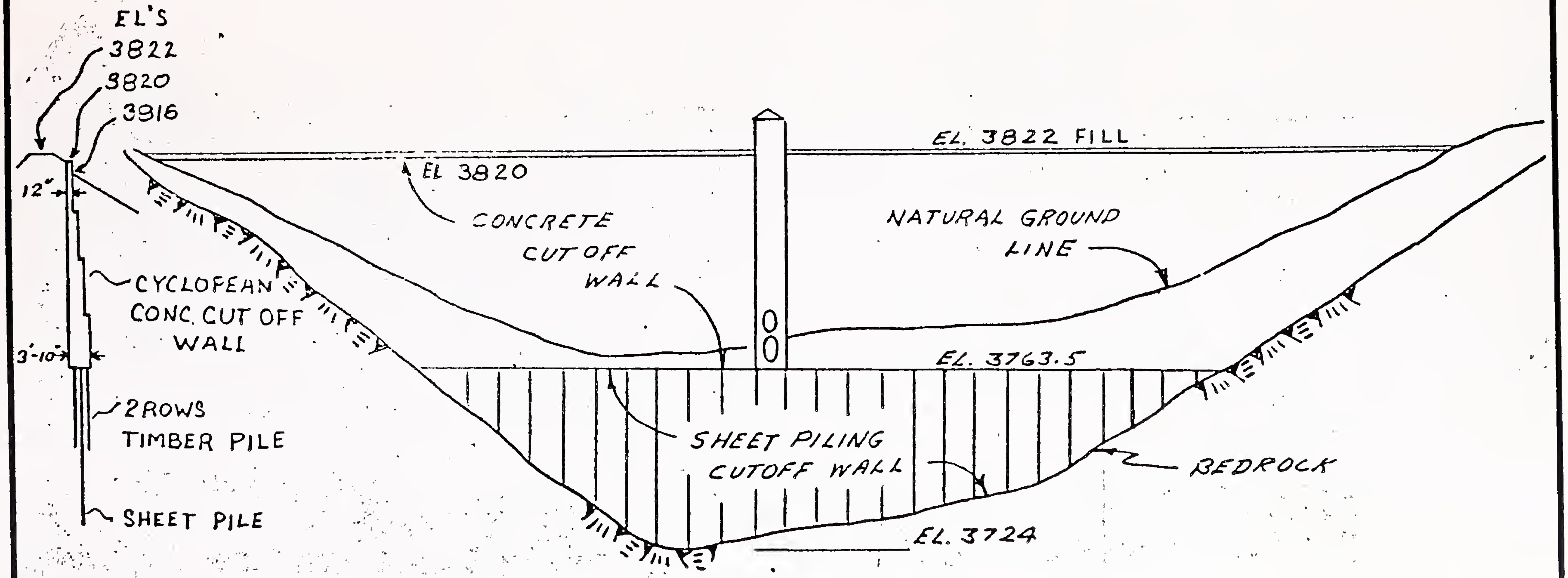
TYPICAL SECTION

N.T.S.

NOTE:
DESCRIPTION OF FILL AND FOUNDATION PREPARATION TAKEN FROM 1914 DRAWINGS ON FILE WITH OWNER

PLATE 7
LAKE FRANCES
NORTH DAM
EMBANKMENT SECTION

CH2M HILL



PROFILE

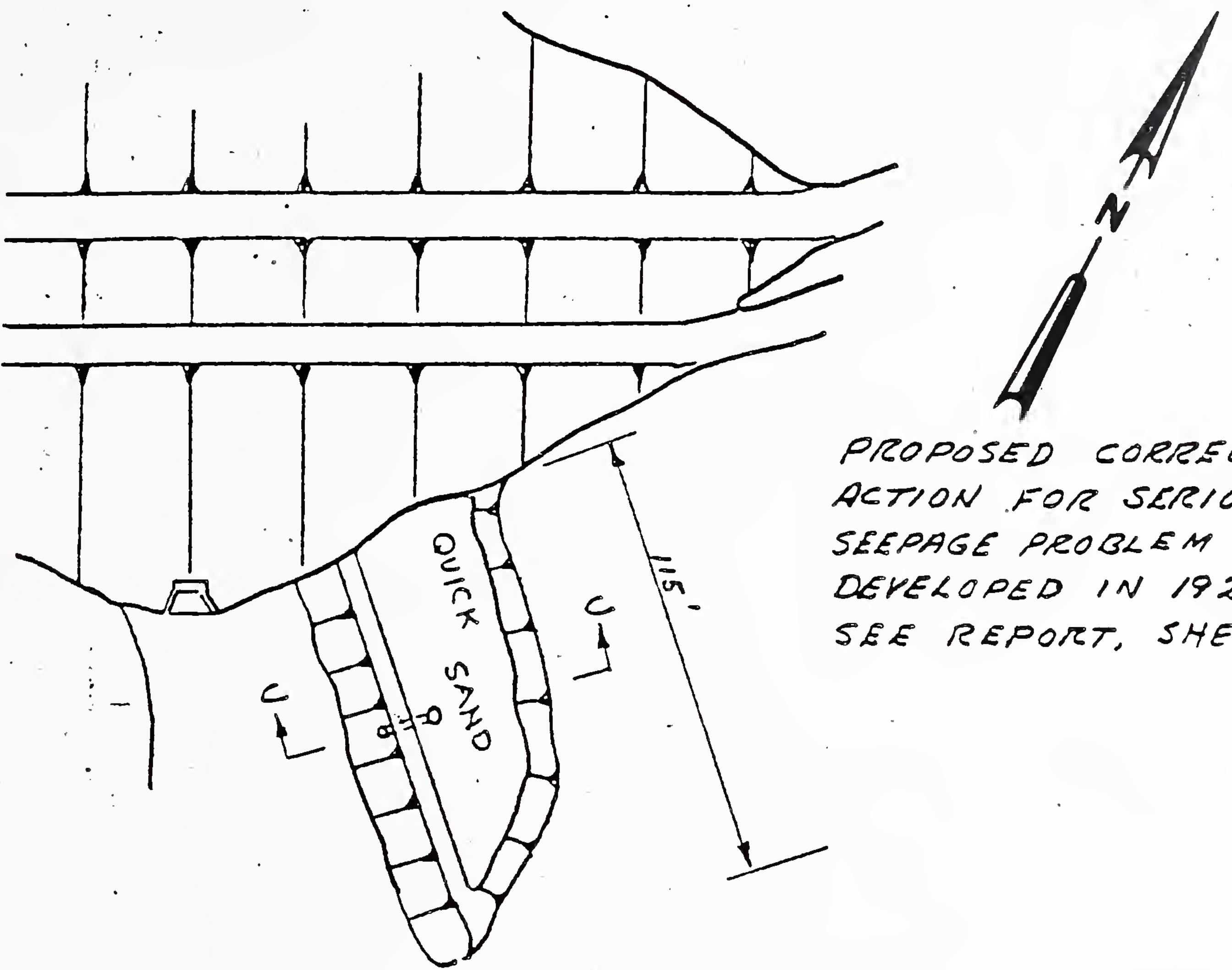
N.T.S.

PLATE 8

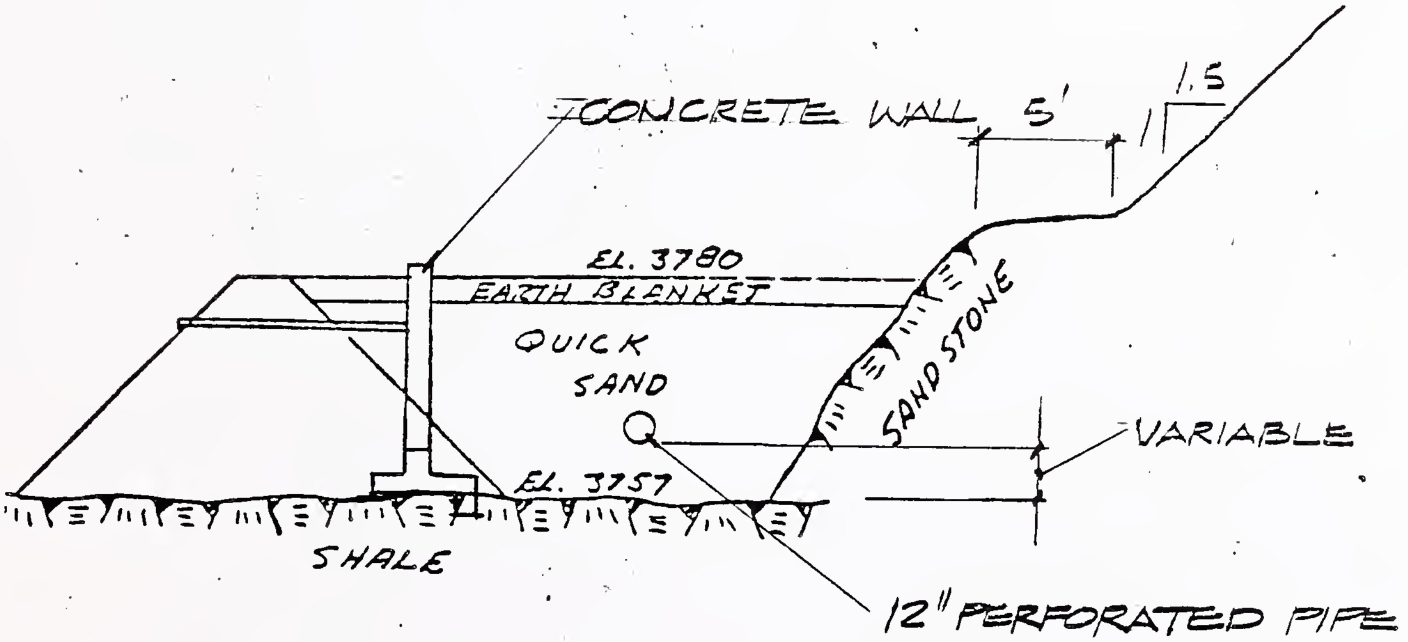
LAKE FRANCES

EAST DAM
EMBANKMENT PROFILE

CH2M HILL



PROPOSED CORRECTIVE ACTION FOR SERIOUS SEEPAGE PROBLEM WHICH DEVELOPED IN 1920
SEE REPORT, SHEET B-2-6



SEC. C-C
NOT TO SCALE

NOTE:
REFERENCE REPORT
BY CORPS OF ENGINEERS
FEB. 1973

PLATE 9
LAKE FRANCES

EAST DAM
ABUTMENT CORRECTION
FOR SEEPAGE PROBLEM

CH2M HILL